This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

B 1,069,455

TENNESSEE GEOLOGICAL SURVEY

BULLETIN 3

Drainage Reclamation in Tennessee

By GEO. H. ASHLEY, and Others

BULLETIN 4

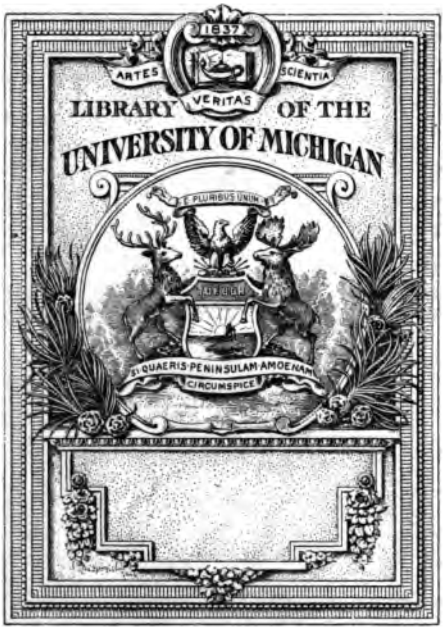
Administrative Report for 1910

By GEO. H. ASHLEY

BULLETIN 5

Clay Deposits of West Tennessee

By WILBUR A. NELSON


LIBRARY OF THE
UNIVERSITY OF MICHIGAN

THE GIFT OF
Tenn. Geol. Survey

QE
165
.A3

STATE OF TENNESSEE
STATE GEOLOGICAL SURVEY
GEO. H. ASHLEY, STATE GEOLOGIST

BULLETIN 3

DRAINAGE RECLAMATION IN TENNESSEE

FIRST PAPERS

DRAINAGE PEOBLEMS IN TENNESSEE.
By Geo. H. Ashley.

PRELIMINARY REPORT UPON THE LANDS OVERFLOWED BY THE NORTH AND MIDDLE FORKS OF FORKED DEER RIVER AND RUTHERFORD FORK OF THE OBION RIVER IN GIBSON COUNTY, TENNESSEE.
By A. E. Morgan and S. H. McCrory.

THE DRAINAGE LAW OF TENNESSEE.

NASHVILLE, TENNESSEE
1910

Folk - Keelin
Printing . Co.

Nashville
Tenn.

0 4 ag 11

Tenn G[illegible] Survey 7-11-19.

State Geological Commission

MALCOLM R. PATTERSON, *Chairman,*
Governor of Tennessee.

JOHN THOMPSON,
State Commissioner of Agriculture.

R. A. SHIFLETT,
Chief Mine Inspector.

BROWN AYRES,
President, University of Tennessee.

J. H. KIRKLAND,
Chancellor of Vanderbilt University.

WM. B. HALL,
Vice-Chancellor, University of the South.

GEORGE H. ASHLEY,
State Geologist.

22[illegible]531

3-A

STATE OF TENNESSEE
STATE GEOLOGICAL SURVEY
GEO. H. ASHLEY, STATE GEOLOGIST

Drainage Problems in Tennessee

BY GEO. H. ASHLEY

EXTRACT (A) FROM BULLETIN No. 3, DRAINAGE RECLAMATION IN TENNESSEE, 1910.

NASHVILLE, TENNESSEE
1910

CONTENTS

Value of alluvial lands 7
Need of their protection 7
Reclamation of glaciated areas 7
Financial return for reclamation 8
How funds are obtained 8
General conditions in West Tennessee 8
Physical condition of drainage in West Tennessee 10
Width of bottom lands 11
Gradient of streams 11
Growth of flood conditions 12
Reclamation problems 12
Stages of reclamation 13
Causes of reclamation values 13
Preliminary data to be collected 13
Planning construction 13
Tennessee Drainage law, passage of 14
State Geological Survey and drainage work 14
Peculiar province of Geological Survey in drainage work 14
Final results 15

DRAINAGE PROBLEMS IN TENNESSEE

BY GEORGE H. ASHLEY.

VALUE OF ALLUVIAL LANDS.

In all places, and at all times, it has been true that the alluvial lands excel all others in fertility and durability. The valley of the Nile, long known as the grainery of the world, is but one example out of thousands. The soil of the bottom lands of the rivers is made up of a mixture of all of the materials derived from the various rocks exposed to weathering in the valley above. At the same time with every flood large quantities of leaves and other vegetation is washed over the flooded lands and deposited with the sand, clay, silt, or other material. These deposits are built up with every flood, gaining in depth from year to year.

NEED OF THEIR PROTECTION.

But it has also been true in most places that the same floods that build up and render these bottom lands fertile have prevented their use for agriculture to a greater or less degree. Where the overflow is not excessive and does not come when crops are growing, it may be possible to carry on a precarious form of agriculture, the fat years making up for the lean years when crops are ruined by overflow. But in most countries, both ancient and modern, these rich bottom lands have been cultivated only after they have been protected from the ravages of floods, either by digging drainage channels or ditches, or by raising levees, or both. The valleys of the Nile, Tigris, Euphrates and Kiang rivers, the English "Fens," and the coastal lands of Holland, are well known examples of such protected or reclaimed lands.

RECLAMATION OF GLACIATED AREA.

The northern United States within the area covered by the great glaciers of the ice age is full of marshy areas formed by irregular dumping of the dirt pushed or carried by the glaciers. In the early times these places were avoided by the settlers as the breeding places for malaria, as valueless for agriculture, as places in which to lose cattle, fit only to harbor wild animals. But during the last few decades, especially, there has come a realization of the agricultural possibilities of these lands, and everywhere they are being drained with most satisfactory results. Lands which before were only a menace to health and life become the richest lands of the region, and people who were eking out a precarious existence on the adjoining hills found the worthless swamps the highway to wealth and prosperity.

FINANCIAL RETURN FOR RECLAMATION.

In the reclamation of these lands it has commonly been found true that the income from one or two crops will pay the cost of the improvements necessary to secure immunity from the floods. On the other hand, the loss of a single crop through inadequate protection has often meant several times as much loss as the additional cost of adequate protection would have been. To be feasible, any land so reclaimed must be worth more than its value before reclamation, plus the cost of reclaiming. Where land worth $10 to $20 an acre can be reclaimed for $10 to $15 an acre, and then be worth $50 to $75 an acre, there can be no doubt as to the feasibility or desirability of its reclamation.

HOW FUNDS ARE OBTAINED.

One of the chief difficulties in the past has been that too often the unreclaimed land has not sufficient value to serve as security for financing the necessary engineering construction. Such reclamation only becomes possible, therefore, when the land owners have other funds or property, or the funds are advanced from some outside source. It is to meet these needs that in recent years most of the States have passed laws enabling counties in which drainage work is needed to advance the necessary money to be paid back in installments after the land comes into production. In that way the land in a few years pays for its own improvement.

GENERAL CONDITIONS IN WEST TENNESSEE.

This general subject has a very live interest for the citizens of Tennessee, because of the large areas, particularly in West Tennessee, that are subject to overflow, and that may be profitably reclaimed. While the larger streams all through the State have more or less bottom lands along their courses, in Middle and East Tennessee these form but a small percentage of the several drainage basins. In some cases, as in Stewart county, the area is quite large, as it is estimated that nearly or quite 50,000 acres of that county are included in the bottoms of the Tennessee and Cumberland rivers and their tributaries. But this is rather exceptional, and in a large number of cases these lands are not so subject to frequent and destructive floods but that they prove valuable for agriculture. But in West Tennessee the bottom lands subject to overflow often form from ten to twenty-five per cent of their respective drainage basins. Thus it has been estimated that in Obion county, 80,000 acres, or about one-fourth of the county, is subject to overflow. In Gibson county a more careful estimate gives the overflow lands an area of about ten per cent. of the total surface. All told, it has been estimated that there are about 1,000,000 acres of land in West Tennessee subject to overflow. Supposing that the reclamation of that land cost $10 an acre, it will call for a total expenditure of $10,000,000. At first sight, that seems like a very large undertaking, but if it be recalled that with the expenditure of such a sum it is almost certain to increase the value of the lands so reclaimed by $50,000,000, and may increase the State's output by $10,000,000 a year, it would seem to be well worth while. The result of such expenditure is well seen in any part of the United States where wise drainage laws have been in effect for some time. Perhaps I can do no better than to quote from a recent report (Illinois State Geological Survey, Bulletin No. 8, pages 56-7.) a description of some of the changes that have been wrought in that State.

> "If one examine the accounts of the early exploration of Illinois he will be constantly impressed with the large amount of swamp land traversed. The impression gained in reading of the winter journey of Colonel Clarke from the Mississippi to the Wabash, at the time he surprised and captured Vincennes, is that the soldiers waded in swamps from one river to the other. Yet, if one traverse the same route now, he will find, in the main, a slightly rolling upland well drained and cultivated, with so little water present that ponds must be made to furnish the boilers of the mills and factories scattered through our areas of cheap coal.
>
> "If, again, one examines the maps of the early land surveys, he sees acres and square miles of our Central Illinois corn belt set aside as swamp lands. The contrast between the territory as it now is, is so great as to have created the suspicion of fraud in the early surveys. Indeed, a few years since the United States land office sent special agents into the State to investigate matters and set at rest, if possible, these suspicions. These agens drove over miles of territory, the original maps in hand, and where swamps were marked by the surveyors, found only well drained, highly productive fields, beautiful groves, substantial barns and handsome houses. They were puzzled and suspicious, but, in the end, after thorough investigation, reported no fraud. The explanation after all is simple.
>
> "Many years ago, some thousands in fact, the great glaciers came down from the north and spread over nearly all of what is now Illinois. In their coming they scraped and shoved along the rocks and soils of the territory invaded, and, when the warm sun melted the ice away, dumped their load in a vast irregular mantle over our older landscape. Our old Illinois is, therefore,

buried 20 to 200 feet deep beneath a mass of rocks, bowlder clay, silt, and soil brought down from the north. The heritage of Canada, the soil patiently prepared by wind, water and sun acting through years on the rough rocks, has been spread out here with lavish generosity and now forms our great fertile prairies. The glacier, however, worked irregularly, and, in dumping its load, paid little attention to existing streamways. It filled up some, diverted others, and created shallow ponds and deep 'kettle holes' over the whole of a formerly well-drained territory. Long as has been the period since the ice melted, it has not been long enough for the slow-eroding rivers to eat their way backward and to drain all these ponds and flat uplands. Only the early stages of river work have been accomplished. They have cut their deep narrow gorges, canyon-like in places, but have not developed the tributaries.

"Such a landscape affords the maximum favorable conditions for artificial drainage, and the people of Illinois were quick to see and to seize their opportunity. By the enactment of wise and far-seeing laws—laws which have been a model to many other States, and which may well serve as a model to more yet—it was made possible for the people of individual areas, large or small, to organize drainage districts and to tax themselves for the reclamation of their land. In a way, the great Sanitary District, with its deep waterway, is only a large drainage tract, and is only doing what many a modest farming community in many parts of the State has already done.

"The drainage districts are permitted to organize, cut ditches, dig canals, build levees where necessary, and, in short, to aid nature in the extension of her streams, so as to carry off the surplus water and convert the swamps and ponds into cornfields and orchards. Above the open ditches the farmers bury long rows of tile, made at some nearby factory, and in a few years the increased yield of crops pays off the bonds, leaving a permanent benefit free of cost. In this way has been accomplished the miracle which puzzled the land inspectors, and in this way has been added millions of dollars to the permanent taxable wealth of the State."

The lands needing reclamation in Tennessee differ from those described, but when reclaimed there will be the same transformation from the present timber-covered bottom lands, with brush-choked streams, muddy roads, sloughs filled with standing water to breed malaria-bearing mosquitoes, suitable only for the ranging of cattle—to valleys and fine farms, "highly productive fields, beautiful groves, substantial barns and handsome houses."

PHYSICAL CONDITION OF DRAINAGE IN WEST TENNESSEE.

West Tennessee has an area of about 10,000 square miles, of which about 1,150 drain to the Tennessee River, and the remaining 8,850 square miles, forming the "Plateau of West Tennessee," drain to the Mississippi. The divide between the two drainage systems is much nearer the Tennessee River, the relative width of the two drainage belts ranging from one to six to one to four. In consequence, the streams flowing to the Tennessee are fairly rapid, while those flowing to the Mississippi have very meandering courses flowing in fairly straight, regular valleys. In most cases it is probably true that the meandering courses of the streams are fully twice as long as the valleys in which they flow. The main streams from north to south are: Obion River, with its North, Middle, South and Rutherford forks, and Reelfoot Creek; the Forked Deer River, with its North, Middle and South forks, emptying into the Obion River near its mouth; Big Hatchie River, of which the principal tributaries are: Rose, Piney, Spring, Clover, and Big Muddy Creeks; Loosahatchie River, receiving the waters of Beaver Dam, Cypress and Big Creeks; and Wolf River; the last named two rivers emptying into the Mississippi at Memphis.

WIDTH OF BOTTOM LANDS.

The valleys of these streams, including only the portion that is subject to flooding, will range from one-fourth of a mile to four miles in width. The Obion and Big Hatchie have bottoms three to four miles wide. The South fork of the Forked Deer has bottoms of about three miles wide; the Middle fork about two miles wide, and the North fork will probably average less than a mile.

GRADIENT OF STREAMS.

There is, as yet, but little data on the grade of these valleys. A line of levels down the North fork of the Forked Deer showed a grade of over four feet to the mile at the head and about one and one-fourth feet per mile where it joins the Middle fork. By taking known elevations of the Mississippi at the mouths of the streams, and of some towns on railroads up the rivers, it may be possible to make an approximation of their grade. From these facts it seems probable that the lower courses of these rivers have a fall of little, if any, above one foot to the mile. This will rise to two feet in the middle courses of the rivers, and to three or four feet per mile in the upper courses. Thus, low water in the Mississippi at the mouth of Obion River is about 225 above tide. The Illinois Central Railroad track at Obion is 289 feet above tide. The difference is 64 feet. Making allowance for the elevation of railroad track at Obion above the level of Obion River at that point, it is evident that the fall is less than one and one-half feet per mile. Hico, on the South fork of the Obion River, has an elevation of 389 feet above tide, which gives a fall of less than two feet to the mile to the mouth of the river. On the North fork of the Forked

Deer River, Trenton has an elevation of 315 feet above tide at the station. Allowing for the elevation at the station above the stream, and assuming the river level at the mouth as 225 feet above tide, and the distance as forty miles, this gives a grade of less than two feet to the mile. Vildo, on the Big Hatchie, has an elevation of 328 feet above tide. Mean low water at the mouth of the river is about 215 feet. Vildo is about fifty-two miles by valley from the mouth, giving, again, a grade of probably a little under two feet per mile. The Loosahatchie and Wolf Rivers again are shorter and have a higher gradient, of probably over three feet per mile.

GROWTH OF FLOOD CONDITIONS.

The flooding of the stream bottoms of West Tennessee is a matter of fairly recent growth. It tends to become worse rather than better. Before this region was deforested, these rivers and streams flowed with good depth all the year round. The rains then were held by the leaves and humus, and found their way to the stream through perennial springs and brooks. There are still living men who can tell of boating on these rivers, and of the time when it was difficult to find fords. As the country has been cleared up and put under cultivation, the rain waters have tended more and more to run quickly and directly to the streams, carrying sand and silt with them. Thus resulted a temporary increase in the water delivered to the stream channels, and at the same time, a decrease in the carrying capacity of the channels through its filling with sand. At the same time the streams have been allowed to become choked up with fallen timber and brush. This tendency toward rapid run-off has continued until today it does not require more than from three to twelve hours after a storm until the waters reach the bottoms. The general result has been that instead of the former fairly uniform flow throughout the year, there is a series of floods following each storm or series of storms, and a practical drying up of the streams in late summer, or during the dry season. The introduction of tile drainage is going to make matters worse, for it will hasten the removal of the water that soaks into the ground.

RECLAMATION PROBLEMS.

The problems of the reclamation of the bottom lands of West Tennessee, therefore, involves four factors: 1. Retardation of the run-off; 2. Preparation of an adequate channel for the greatest present and future run-off; 3. The prevention of the filling of the channels by sand or other material; 4. The clearing and secondary drainage and preparation of the bottoms reclaimed.

STAGES OF RECLAMATION.

The reclamation work itself will involve four stages: (1) The collection of data on which to base plans for the work; (2) the planning and the location of the work on the ground; (3) the construction of the work; and (4) the financing of the work.

CAUSES OF RECLAMATION FAILURES.

In the past large amounts of money have been wasted through not securing sufficient data before beginning work, or through poorly conceived plans. Nearly every State where reclamation projects have been under way for a long time can point to numerous exeamples of drainage construction that have had to be reconstructed, with too often the entire loss of the cost of the first construction. Sometimes the levees are not high enough or far enough apart; sometimes they are built of silt of a form suitable for clay, and they wash away; sometimes stumps or logs have been left in the foundation, or the muck ditch was omitted; sometimes a layer of water bearing sand ran under the levee and ultimately undermined it; sometimes the hill wash came down and filled the channels, or the "hill water" proved to be more than could be disposed of, or it may have been one of a hundred other causes.

PRELIMINARY DATA TO BE COLLECTED.

- The data first to be collected includes: the rainfall, both general and special; the area drained by each stream, the run-off, the slopes of the surface, the character of the soil, sand contained in the run-off, the capacity and shape of the present channel, the detailed topography of the valley bottoms (for the planning of the new channels, levees, the drainage of the lands back of the levees, etc.).

PLANNING CONSTRUCTION.

'With this data in hand, it may be found that all that is necessary is the clearing of the channel of the stream of all obstructions, including the growth on its banks; or it may be necessary to straighten the channel as well, so as to increase its grade and rate of run-off; it may be necessary to enlarge, as well as straighten the channel; or still further it may be necessary to construct an outer channel by raising levees either side of the channel and at some distance back. In most cases in West Tennessee it is probable that the last plan may have to be adopted. Just how high the levees should be, and how far back, is a matter of calculation from the data collected, using known formulæ of stream flow. It is here that the data collected becomes of value; for if the levees are not high enough or far enough apart, they would be of little or no value. On the other hand, if they are made larger than necessary, money is wasted in their construction. A knowledge of the behavior of various materials is necessary in planning the levees, for a levee built of sand or silt has to be of different construction from one of clay.

TENNESSEE DRAINAGE LAW, PASSAGE OF.

In Tennessee, drainage work has been made possible through the passage of a drainage law by the Legislature of 1909. This law provides for the formation of drainage districts, and all of the necessary machinery for legalizing the necessary condemnations and assessments, for supplying the funds through the county and for the refunding of such moneys by districts benefited, and for the necessary surveying and engineering control, and all other details. This law is published separately in another part of this bulletin.

STATE GEOLOGICAL SURVEY AND DRAINAGE WORK.

At the same time the organic law of the State Geological Survey provided as one of its objects and duties "a study of the swamps and other non-tillable lands of the State, with reference to their reclamation for agricultural purposes." In pursuance of this provision of the law, and in recognition of the need and the great benefit to the State, as well as to the people locally of the reclamation work, the State Geological Survey has, from the first, entered heartily into coöperation in such work, and has devoted a large share of its funds to such coöperation. It has felt that its share in the work should be in the making of the necessary preliminary studies and surveys, in coördinating the work between the several districts, so that plans and constructions carried out in one district would be in harmony with those of another district, and in securing such coöperation from the Federal Bureaus as it could.

PECULIAR PROVINCE OF GEOLOGICAL SURVEY IN DRAINAGE WORK.

Where, as is often the case, there are two or more drainage districts on the same stream, it is of vital importance that the work in these several districts be coördinated in order that construction in one district shall not produce conditions in the other districts detrimental to those districts, either by constricting the channel between the levees so as to back water up on a district above, or by hastening the on-flow of waters through one district, to add to the flooded conditions of the next district below. The Geological Survey had felt it to be peculiarly its province to assist in securing such coördination. Again, many of the studies, as of rainfall and run-off, are general in their nature, and data secured in one district is of value in all the districts. It is hoped by coöperation with the Drainage Investigations Division of the U. S. Department of Agriculture, to secure much data of this kind that will be necessary in making plans for the drainage construction in the several districts, and so prevent the necessity of each district securing this data for itself.

FINAL RESULTS.

As for final results, perhaps no better statement can be made than that given by Judge John S. Cooper in an address published in 1908:

> "West Tennessee is already the most densely populated grand division of the State, and taken as a whole, is now the most desirable portion of the State for agriculture. With these bottoms made susceptible of safe cultivation, and the health of the region, which is already good, made much better by such drainage, with an inexhaustible supply of the finest drinking water in the world now obtained from the deep wells of the plateau region, with excellent facilities for transportation already, and with some of these rivers further utilized for navigation, and even for irrigating many portions of their flood-plains, prophecies for the future of this region could, perhaps, hardly be too sanguine."

3-B

STATE OF TENNESSEE
STATE GEOLOGICAL SURVEY
G. H. ASHLEY,
State Geologist

U. S. DEPT. of AGRICULTURE
OFFICE OF EXPERIMENT STATIONS,
DRAINAGE INVESTIGATIONS,
C. G. ELLIOTT, Chief.

PRELIMINARY REPORT

UPON THE

DRAINAGE OF THE LANDS OVERFLOWED

BY THE

North and Middle Forks of the Forked Deer River

AND THE

Rutherford Fork of the Obion River

IN

Gibson County, Tennessee

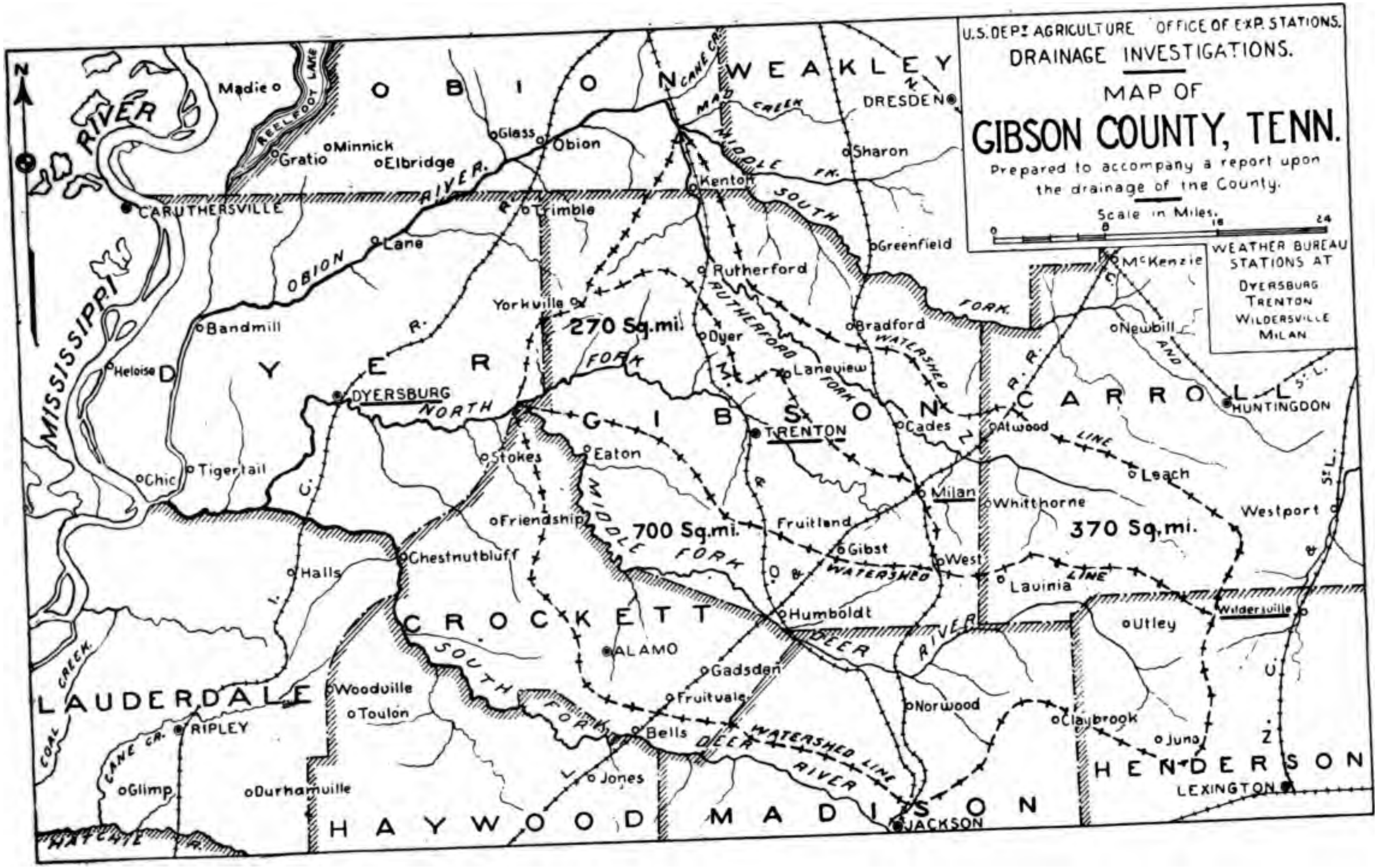
BY

A. E. MORGAN and S. H. McCRORY
Drainage Engineers, U. S. Department of Agriculture

NASHVILLE, TENNESSEE
1910

CONTENTS

Introduction 21
Description of territory 21
Run-off 22
    Units of measurement 22
    Rain fall 22
    Discussion of run-off 30
Description of streams 32
    Rutherford Fork of the Obion River 32
    Drainage condition 32
    North fork of the Forked Deer River 32
    Middle fork of the Forked Deer River 33
Drainage conditions 34
Soil erosion and silting of channels 35
    Control of soil erosion and deposits 35
        Control by collecting ditches 36
        Collecting basins 37
    Prevention of erosion 37
    Enlarging of channels by erosion 38
What constitutes reclamation 38
Plan of improvement 40
Benefits 41
Survey 41
Recommendations 42



U.S. DEPT. AGRICULTURE OFFICE OF EXP. STATIONS.

DRAINAGE INVESTIGATIONS.

MAP OF

GIBSON COUNTY, TENN.

Prepared to accompany a report upon the drainage of the County.

PRELIMINARY REPORT

Drainage of Lands Overflowed in Gibson County

By A. E. MORGAN and S. H. McCRORY

INTRODUCTION.

In May, 1910, a coöperative agreement was made between C. G. Elliott, Chief of Drainage Investigations of the Office of Experiment Stations, U. S. Department of Agriculture, and Geo. H. Ashley, State Geologist of Tennessee, under the terms of which Drainage Investigations agreed to make an examination of the Rutherford Fork of the Obion River and the North and Middle Forks of the Forked Deer River; and to suggest a plan for draining the overflowed lands along these streams. A. E. Morgan and S. H. McCrory, drainage engineers of the Office of Experiment Stations, were detailed for the work, and before entering upon their duties attended a meeting of the committee having charge of the drainage work in Gibson county, Tenn., held at Trenton on May 13th, 1910, which meeting was also attended by Mr. Ashley.

The following report contains suggestions based upon information obtained by personal examination of the streams and their watersheds, and represents the judgment of the engineers as to their respective drainage capacities and requirements. The data relating to the fall on the North Fork of the Forked Deer River was obtained from surveys made by H. P. Farrar for the Drainage District that has been formed for the improvement of this stream.

This report presents the drainage problems as they exist in the territory examined, and submits a review of the estimated cost of draining the flooded land along the North Fork. It discusses the necessity of adequate preliminary surveys and of careful stream investigations.

DESCRIPTION OF TERRITORY.

The territory considered in this report includes the watersheds of the Rutherford Fork of the Obion River and of the North and Middle Forks of the Forked Deer River. Rutherford Fork drains approximately 370 square miles, North Fork 270 square miles, and Middle Fork 700 square miles. The principal towns in the area examined are Rutherford, Trenton, Humboldt, Dyer, Milan, and Eaton. The Mobile and Ohio R. R. crosses the territory from north to south, and the Illinois Central and Louisville and Nashville Railroads cross the head waters of the streams. The staple crops of the region are corn, cotton, wheat, and hay; and in parts of the country small fruits and vegetables. The soil along the streams is a silt loam, generally a dark brown color. The soil on the uplands is loam or silt loam, varying in the different parts of the territory. Nearly all the well drained land is cultivated or used for pasture. Only a small part of the river bottoms is cultivated, the remainder being used for pasture.

RUN-OFF.

Of all the water that falls upon a given area as rain or snow, a part is returned to the air by evaporation, part sinks deep into the ground, and the remainder flows over or through the ground to the streams, and through them passes out of the country as run-off.

UNITS OF MEASUREMENT.

In discussing run-off in its relation to rainfall it is usual to express the rate in inches of depth in 24 hours over the entire watershed, or in cubic feet per second per square mile for the watershed area.

RAINFALL.

Rainfall is the most important element to be considered in the estimation of the run-off. The streams examined are in a region of abundant rainfall, the average precipitation being about 50 inches in a year. The maximum annual rainfall of which we have a record is 72.56 inches at Trenton, Tenn., in 1884, and the minimum is 38.64 inches at Kenton, Tenn., in 1904.

The heaviest rains occur in the Winter or early Spring, while the driest season is in September and October. The heaviest month's rain of which we have a record occurred during January, 1898, when an average of 13.78 inches fell over the entire area drained by the three streams. There are several months for which no precipitation is recorded at any station.

Tables 1 to 4 were compiled by the Weather Bureau and show the monthly, annual and average rainfall at four stations in the watersheds of the streams examined,

TABLE NO. 1.

Showing Monthly, Annual and Average Precipitation (in inches and hundredths) at Dyersburg, Dyer County, Tenn. Elevation 310 feet.

YEAR	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1883	------	------	------	------	3.26	4.76	6.45	4.00	0.63	5.22	1.99	2.48	------
1884	2.60	8.69	3.48	3.94	4.06	4.09	6.12	2.41	3.27	2.02	2.13	8.85	51.66
1885	5.59	1.55	1.67	6.15	3.25	6.98	4.59	1.04	2.94	1.74	------	------	------
1886	------	------	------	------	5.41	5.06	1.76	3.31	2.51	0.92	------	------	------
1887	------	------	------	------	2.06	2.44	2.92	2.70	4.59	0.68	------	------	------
1888	------	------	------	1.60	3.77	3.08	1.38	11.75	0.92	2.72	------	------	------
1889	------	------	------	------	2.36	8.16	5.92	1.42	6.64	0.94	8.71	0.60	------
1890	7.07	8.05	5.28	5.04	3.96	2.06	2.13	3.84	5.54	2.68	4.47	------	------
1891	------	------	------	------	1.59	9.13	4.03	1.42	1.69	1.61	11.45	5.05	------
1892	1.68	3.44	2.67	10.45	6.62	4.18	5.68	4.12	0.94	0.33	4.87	------	------
1893	------	------	------	------	7.63	1.84	2.17	0.07	6.64	2.74	4.36	------	------
1894	------	------	------	------	3.73	0.76	5.62	2.56	1.50	0.27	0.00	------	------
1895	------	------	------	------	2.78	0.73	4.77	1.99	1.06	1.01	7.66	3.76	------
1896	3.16	1.93	6.07	4.03	4.92	5.29	3.57	1.75	3.54	2.53	5.66	------	------
1897	------	3.13	10.75	6.43	1.32	2.54	2.11	0.63	0.00	0.75	3.67	------	------
1898	13.93	1.88	3.49	4.91	4.42	3.34	3.49	3.44	4.35	4.02	------	------	------
1899	------	------	------	------	4.48	2.90	3.58	3.00	1.10	2.47	3.23	------	------
1900	------	------	------	------	2.12	11.19	4.04	0.87	7.33	7.49	------	------	------
1901	------	------	------	7.37	3.60	0.21	1.15	4.40	2.72	3.55	------	------	------
1902	------	------	------	------	2.06	3.97	0.25	4.92	1.74	2.70	------	------	------
1903	------	------	------	------	2.50	0.58	1.41	0.48	0.53	0.72	------	------	------
1904	------	2.32	5.70	3.75	3.36	2.73	4.03	2.38	4.96	1.00	0.59	5.75	------
1905	1.92	1.66	3.17	3.50	9.84	6.21	4.20	4.81	1.60	5.35	3.45	4.75	50.46
1906	5.40	1.62	8.08	2.77	4.11	2.47	4.88	5.79	6.21	1.76	12.63	8.08	63.80
1907	5.90	5.08	3.13	7.54	10.43	3.58	2.69	2.69	1.80	4.20	5.00	3.36	55.40
1908	1.70	7.60	4.05	6.40	3.59	5.75	1.54	5.35	1.32	T	7.30	1.45	46.05
Months	**4.94**	**3.91**	**4.80**	**5.28**	**4.12**	**4.00**	**3.48**	**3.12**	**2.93**	**2.29**	**5.13**	**4.41**	**48.41**

TABLE NO. 2.

Showing Monthly, Annual and Average Precipitation (in inches and hundredths) at Kenton, Obion County, Tenn. Elevation 360 feet.

YEAR	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1902	------	------	------	2.58	2.57	2.58	T	4.76	3.20	3.51	4.79	10.53	------
1903	2.69	8.34	5.45	3.32	4.67	1.87	3.00	1.44	0.75	0.77	3.29	4.71	40.30
1904	4.72	2.53	5.06	4.03	2.32	2.74	3.10	2.15	2.92	0.94	0.70	7.43	38.64
1905	3.00	2.17	3.33	4.56	4.34	4.28	8.26	3.32	2.45	4.38	3.23	4.48	47.80
1906	5.15	1.39	7.53	2.48	3.52	1.99	4.73	4.25	5.20	1.78	13.09	7.81	58.92
1907	5.41	5.68	4.46	6.25	10.19	4.87	6.32	2.65	1.85	3.87	4.15	3.67	59.37
1908	2.71	4.89	4.24	8.25	4.37	7.31	1.73	3.34	0.41	T	8.12	1.65	47.02
Months	**3.95**	**4.17**	**5.01**	**4.50**	**4.57**	**3.66**	**3.88**	**3.13**	**2.40**	**2.18**	**5.34**	**5.75**	**48.54**

TABLE NO. 3.

Showing Monthly, Annual and Average Precipitation (in inches and hundredths) at Trenton, Gibson County, Tenn. Elevation 345 feet.

YEAR	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1869	------	3.15	5.93	9.00	3.30	3.80	7.00	5.70	1.30	2.60	5.50	5.30	------
1870	5.58	4.41	4.32	2.90	4.70	5.60	1.80	3.40	1.70	2.90	------	------	------
1871	4.05	3.00	8.20	7.75	3.60	2.80	3.20	2.60	1.70	4.20	1.22	2.50	44.82
1872	1.44	3.30	1.80	7.60	3.00	5.00	4.30	------	3.65	1.60	1.70	1.87	------
1873	3.66	------	------	------	------	------	------	------	------	------	------	------	------
1883	------	------	------	------	------	------	------	4.57	0.96	12.83	5.80	7.74	------
1884	7.36	10.71	7.75	8.77	8.64	3.77	5.93	2.55	5.91	2.17	1.95	7.14	72.65
1885	6.98	1.96	2.46	3.84	4.50	6.78	4.43	1.26	3.49	2.26	2.52	3.18	43.66
1886	6.16	6.74	3.74	5.06	4.37	4.14	1.28	2.92	4.19	0.86	7.73	2.36	49.55
1887	4.97	8.23	2.86	1.68	3.17	2.21	2.73	2.83	3.50	1.99	2.77	4.01	40.95
1888	4.73	2.14	5.72	1.63	4.19	3.89	1.18	8.62	1.94	2.85	5.16	2.15	44.20
1889	5.25	1.74	3.32	1.51	3.74	8.33	2.69	1.02	6.43	1.15	9.83	0.93	45.81
1890	7.70	8.50	8.31	4.48	3.11	4.85	0.50	8.58	4.90	2.48	5.49	5.09	63.99
1891	7.77	5.40	7.70	4.36	1.24	8.06	6.74	2.44	1.39	0.80	7.60	6.50	60.00
1892	------	------	------	------	------	------	------	------	------	------	------	------	------
1893	------	------	------	------	------	3.06	2.42	T	6.98	2.32	4.90	4.50	------
1894	3.99	8.90	6.57	6.74	3.49	1.17	4.11	2.58	2.00	0.47	0.46	------	------
1895	------	------	6.36	0.91	1.83	1.81	4.59	0.03	1.62	0.77	7.23	3.95	------
1896	2.26	3.81	6.94	2.66	5.95	4.92	3.87	4.24	2.77	1.77	8.37	1.11	48.67
1897	4.67	4.13	7.70	6.10	0.98	2.58	1.56	1.62	T	1.95	4.32	4.17	39.78
1898	14.86	1.99	6.74	4.59	3.92	3.73	4.67	2.07	5.04	6.50	3.20	3.80	61.11
1899	6.60	3.64	4.77	2.57	4.47	2.11	4.04	0.79	0.47	2.71	2.91	4.00	39.08
1900	------	------	1.83	2.99	2.12	12.05	1.96	1.24	4.71	4.01	7.40	------	------
1901	------	------	------	------	------	------	------	10.52	2.05	2.23	1.99	4.74	------
1902	6.92	3.70	5.84	2.28	------	------	------	------	3.01	3.10	4.20	10.19	------
1903	3.16	8.76	5.05	3.95	5.54	3.34	4.44	1.33	0.55	1.57	3.10	5.45	46.24
1904	5.05	1.36	5.70	5.17	3.17	1.87	3.39	1.99	4.50	1.26	1.21	7.57	42.24
1905	4.58	2.75	4.21	4.27	5.23	5.94	4.61	1.94	1.90	5.18	5.47	3.82	49.90
1906	3.76	1.46	5.81	3.72	1.28	1.98	1.71	4.08	5.08	1.90	13.79	7.59	52.16
1907	4.55	5.74	3.60	5.90	7.79	1.97	1.29	1.30	3.47	4.26	4.68	3.86	48.41
1908	3.13	4.34	4.88	6.11	4.15	6.10	2.18	3.43	0.49	T	7.24	1.81	43.86
Months	5.38	4.58	5.31	4.48	3.90	4.30	3.33	3.10	2.96	2.71	4.92	4.44	49.41

TABLE NO. 4.

Showing Monthly, Annual and Average Precipitation (in inches and hundredths) at Wildersville, Henderson County, Tenn. Elevation 400 feet.

YEAR	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1885	------	------	------	------	------	------	------	------	------	2.10	3.08	1.75	------
1886	6.17	5.95	2.95	------	------	------	------	------	------	------	------	------	------
1897	------	------	------	------	------	------	------	------	------	0.96	4.22	6.08	------
1898	12.55	1.48	5.60	4.25	4.42	3.56	5.15	2.34	3.27	2.71	3.66	2.92	51.91
1899	7.95	6.36	6.96	5.25	5.37	4.65	4.00	2.70	0.38	3.01	3.52	5.22	55.37
1900	2.56	6.39	3.16	3.67	3.93	15.85	2.33	4.51	4.78	6.50	7.48	2.98	64.14
1901	4.28	2.32	3.40	3.44	3.74	1.93	1.63	9.08	2.60	1.75	2.05	5.38	41.60
1902	5.21	1.68	9.42	4.73	4.59	3.36	2.65	8.25	2.69	1.58	4.25	9.64	58.05
1903	2.59	7.39	4.67	2.56	6.05	2.39	6.37	------	0.30	1.18	3.58	4.95	------
1904	4.70	0.95	5.70	3.75	3.57	3.87	5.82	3.77	3.15	2.90	1.15	8.60	47.93
1905	3.02	1.25	4.34	3.08	7.21	5.93	4.98	4.01	2.29	6.21	2.09	4.49	48.90
1906	4.85	0.76	3.62	2.88	------	2.60	3.64	4.37	5.38	3.30	12.18	6.93	------
1907	4.29	4.20	4.86	5.62	9.91	1.08	2.85	2.58	2.87	4.53	4.18	------	------
1908	------	------	------	3.94	3.65	4.49	1.81	4.21	0.77	0.00	4.09	1.95	------
Months	**5.29**	**3.52**	**4.97**	**3.92**	**5.24**	**4.52**	**3.75**	**4.58**	**2.59**	**2.83**	**4.27**	**5.07**	**50.55**

As the record at Milan is incomplete, no table was compiled for this Station.

TABLE NO. 5.

Storm periods for the years 1897 to 1909, inclusive, as shown by the records of the U. S. Weather Bureau Stations at Dyersburg, Milan, Trenton and Wildersville, Tenn.

1897

	APRIL				SEPTEMBER	DECEMBER					
	1	2	3	4	For Month	17	18	19	20	21	22
*r*Dyersburg	.60	----	.49	1.51	None	----	----	----	----	----	----
*r*Milan	.98	----	*s*	2.05	Trace	----	----	----	----	----	----
Trenton	.55	----	.80	1.02	Trace	.28	.03	.05	2.23	.25	.02
Wildersville	----	----	----	----	----	.43	.06	.25	2.08	.50	.25

r December missing. *s* Missing.

1898

	JANUARY														
	5	6	8	9	10	11	12	14	15	19	20	22	25	30	31
Dyersburg	.06	.36	----	----	.09	2.54	.80	2.30	.24	2.60	.95	2.80	1.09	.10	----
*r*Milan	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Trenton	T	.61	.05	.01	.62	1.85	.90	2.18	.78	2.42	1.25	3.36	.76	.07	----
Wildersville	T	.62	.02	----	.06	2.00	.80	2.04	.87	1.65	.75	2.93	.53	.07	.01

r January missing.

	MARCH							MAY			SEPTEMBER			
	12	13	14	15	16	17	18	20	21	22	21	22	29	30
Dyersburg	----	.37	----	.48	----	.72	.12	1.03	.30	1.52	.69	1.33	----	1.10
*r*Milan	----	----	----	----	----	----	----	1.07	.01	1.65	.35	1.30	----	.80
Trenton	T	.76	----	3.44	----	.16	.02	1.02	.09	1.68	.43	1.27	.26	1.59
Wildersville	T	1.00	T	.94	.39	----	----	1.63	----	1.94	.35	.23	.17	1.87

r March missing.

1899

	JANUARY						FEB.		MAY				JULY					
	9	10	11	12	13	14	25	26	10	11	12	13	21	22	23	24	25	26
*r*Dyersburg	----	----	----	----	----	----	----	----	.43	*s*	.90	.40	.47	.09	1.21	.73	----	.27
*r*Milan	----	----	----	----	----	----	----	----	.35	.69	.20	.65	.90	.10	2.50	.20	.55	.52
Trenton	.05	.73	.34	.10	1.50	.49	1.38	----	.13	.20	.42	T	1.36	1.69	.28	T	.25	----
Wildersville	T	----	1.10	T	1.54	.53	.30	2.05	T	.68	2.00	----	.75	.28	2.43	.22	T	----

r January and February missing. *s* Missing.

(Table No. 5 Continued)

1900

	FEBRUARY					MAY			JUNE									
	7	8	20	21	22	29	30	31	1	2	3	4	5	6	7	8	13	14
*r*Dyersburg	----	----	----	----	----	----	.30	.67	1.18	----	----	.40	.13	.32	----	.14	----	.80
*r*Milan	----	----	----	----	----	T	.50	.23	1.18	T	.56	.25	.43	.80	.03	1.50	----	1.43
*r*Trenton	----	----	----	----	----	.02	.10	.38	.38	----	.34	.12	.04	.20	.05	1.13	----	1.15
Wildersville	.70	2.05	.08	1.80	.06	.50	.35	.82	.38	1.60	.08	.18	.20	.45	.82	----	T	2.80

r February missing.

	JUNE																Total Month
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Dyersburg	3.20	----	----	----	.22	----	----	----	.68	.58	.03	2.20	1.31	----	----	----	11.19
Milan	2.35	.07	.03	2.47	T	----	.24	----	.97	.27	.87	.55	.43	----	----	----	16.38
Trenton	2.03	T	.05	1.56	.18	.04	----	T	.64	.25	1.83	1.61	.45	T	T	----	12.05
Wildersville	.16	.88	----	.72	----	----	.02	2.33	----	1.76	.22	2.60	.04	.55	----	.06	15.85

	AUGUST			SEPTEMBER							
	29	30	31	1	2	3	20	21	22	23	24
Dyersburg	----	.27	.15	.17	----	.43	1.25	2.15	----	1.50	1.75
Milan	----	.30	.27	2.00	.55	.10	1.60	.65	.05	1.30	----
Trenton	T	.03	.35	.43	----	T	.20	.23	1.49	----	----
Wildersville	.60	----	2.30	1.70	----	----	.74	.08	1.52	.07	----

	OCTOBER				NOVEMBER					
	6	7	8	22	19	20	21	23	24	25
*r*Dyersburg	.39	M	1.64	2.18	----	----	----	----	----	----
*r*Milan	.02	1.25	.40	2.00	----	----	----	----	----	----
Trenton	T	.30	.80	1.75	1.47	3.49	----	.75	1.37	.20
Wildersville	----	.66	3.00	1.20	.36	2.86	1.98	.94	.72	.62

r November missing.

1901

	APRIL		AUGUST									
	17	18	12	13	14	15	16	17	18	19	20	21
Dyersburg	----	2.52	----	----	.25	.50	----	1.75	.15	.60	----	.05
Milan	.10	1.00	1.52	----	.50	1.20	.15	1.78	.90	.50	.52	1.60
*r*Trenton	----	----	.60	T	2.75	1.25	----	.65	----	1.69	2.05	----
Wildersville	.60	.30	T	.56	1.70	----	1.80	.54	.76	.65	1.53	----

r April missing.

	SEPTEMBER				OCTOBER			DECEMBER			
	13	14	15	17	11	12	13	8	9	13	14
*r*Dyersburg	----	1.50	.05	1.17	----	2.15	1.25	----	----	----	----
*r*Milan	----	2.20	.50	.12	----	.40	.90	----	----	----	----
Trenton	2.05	----	T	----	1.89	T	----	.46	1.88	----	2.00
Wildersville	----	2.56	.04	----	----	1.70	----	.86	1.14	.40	.60

r December missing.

(Table No. 5 Continued)

1902

	MARCH					AUGUST			OCT.	
	26	27	28	29	30	26	27	28	3	4
*r*Dyersburg	----	----	----	----	----	----	.95	1.25	1.20	1.35
Kenton	1.01	----	2.31	.03	.24	.20	2.02	.02	3.10	.20
*r*Milan	----	----	----	----	----	----	.59	1.05	.55	1.50
*s*Trenton	1.31	----	2.23	.05	.24	----	----	----	2.50	T
Wildersville	1.25	T	4.05	----	----	.05	2.05	.65	.38	----

r **March missing.** ***s*** **August missing.**

	NOVEMBER				DECEMBER					
	24	25	26	27	11	12	13	14	15	
*r*Dyersburg	----	----	----	----	----	----	----	----	----	Followed by four days without rain.
Kenton	1.16	1.10	.12	.04	.04	.65	.07	1.40	6.03	
*r*Milan	----	----	----	----	----	----	----	----	----	
Trenton	1.26	1.06	.18	.02	T	1.10	.08	1.36	4.90	
Wildersville	1.50	1.15	----	T	T	.30	----	1.50	3.94	

r **November and December missing.**

1903

	FEBRUARY			MARCH						JULY		DEC.	
	14	15	16	5	6	7	8	9	10	30	31	19	20
*r*Dyersburg	----	----	----	----	----	----	----	----	----	.10	1.25	----	----
Kenton	1.15	2.30	.60	.70	2.00	.17	1.00	----	.69	.02	.96	2.43	.52
*r*Milan	----	----	----	----	----	----	----	----	----	.22	2.25	----	----
Trenton	.72	2.44	1.02	.28	2.00	.47	.75	.04	.82	.27	2.00	2.50	.65
Wildersville	.31	.98	1.00	.65	.78	.10	.60	----	2.16	.14	3.30	1.75	1.00

r **February, March and December missing.**

1904

	SEPT.		DECEMBER			
	3	4	24	25	26	27
Dyersburg	.31	.95	.75	.50	.50	3.10
Kenton	1.00	----	.77	----	*s*	5.38
*r*Milan	2.10	.20	----	----	----	----
Trenton	2.20	----	.95	----	2.50	2.60
Wildersville	2.30	----	1.90	----	2.30	2.60

r **December missing.** ***s*** **Missing.**

1905

	MAY					AUG.		OCTOBER			NOV.		DEC.	
	19	20	21	22	23	9	10	18	19	20	28	29	1	2
Dyersburg	.50	.05	T	----	3.64	----	2.30	----	.98	1.57	----	2.40	T	2.35
Kenton	.19	----	----	1.27	.28	----	1.40	.91	1.64	.03	.15	2.09	.20	2.25
Milan	.36	.03	.04	.06	2.45	.00	0.06	----	1.80	.92	T	3.90	T	1.58
Trenton	.50	----	1.20	.30	----	----	----	1.00	----	1.10	----	4.70	.16	1.67
Wildersville	.55	T	T	.40	1.65	----	.36	.72	2.20	.27	T	1.00	T	1.00

(Table No. 5 Continued)

7.00—24 HOUR MAXIMUM.

1906

	JAN.		SEPTEMBER						OCTOBER					
	21	22	25	26	27	28	29	30	1	2	3	4	5	6
Dyersburg	T	3.90	T	1.60	.44	1.54	1.35	.13	.47	T	.89	----	T	.20
Kenton	1.23	2.18	1.19	.44	.35	1.34	.29	.23	.13	.70	.34	----	.21	.04
*r*Milan	----	----	T	.42	.56	1.20	.45	.05	2.52	.05	1.28	.86	.03	.36
Trenton	.45	1.88	.63	.56	.11	1.24	.28	1.34	.54	.95	.15	----	.26	----
Wildersville	1.00	1.80	T	1.80	.10	1.40	T	.98	.20	1.30	1.12	----	.40	.20

***r*January missing.**

	NOVEMBER					DECEMBER		
	17	18	19	20	21	15	16	17
Dyersburg	2.00	4.50	.20	1.50	3.00	1.50	1.35	.80
Kenton	4.42	2.03	.88	2.00	2.24	1.78	1.52	.53
Milan	2.11	4.90	.30	1.50	2.55	1.05	1.60	.97
Trenton	6.47	T	2.28	1.45	2.25	1.43	1.05	.64
Wildersville	7.00	.50	.40	2.50	.60	.40	2.40	.31

1907

	JANUARY			APRIL					MAY					
	2	3	4	26	27	28	29	30	6	7	8	9	10	11
Dyersburg	1.17	1.88	1.00	.15	.20	.15	T	2.80	3.35	1.60	1.00	.80	.15	.65
Kenton	.60	2.28	.08	.11	T	.45	----	2.49	3.80	.77	1.48	.06	1.10	.02
*r*Milan	----	----	----	.14	.10	1.07	.25	1.49	3.12	1.58	.78	.33	----	.27
Trenton	.27	1.47	.07	.27	----	.48	----	1.73	3.00	.74	.95	.05	.58	----
Wildersville	.62	.25	1.50	.20	----	.76	----	1.80	4.00	.35	1.30	----	.30	----

***r*January missing.**

1908

	JUNE		AUGUST			NOVEMBER							
	29	30	18	19	20	23	24	25	26	27	28	29	30
Dyersburg	T	.40	----	.50	2.00	----	2.20	----	.60	----	.40	.65	.90
Kenton	2.42	.23	.94	.02	.26	.78	.52	T	----	----	----	2.88	.54
Milan	----	.64	----	T	.12	----	.53	.02	.81	----	.05	1.66	.10
Trenton	.58	.53	----	----	.08	.19	----	.93	----	1.73	.51	1.08	----
Wildersville	.25	.54	.85	.02	----	T	.27	----	.61	---	.82	.18	.40

1909

	FEBRUARY						APRIL			MAY	
	11	12	13	14	15	16	6	7	13	19	20
Dyersburg	----	.20	.10	1.10	.80	T	----	1.67	2.70	----	2.00
Kenton	T	.41	.01	----	1.92	.05	1.61	.07	2.76	----	2.92
Milan	----	.08	.37	2.00	1.05	.12	.02	3.05	2.43	----	2.19
Trenton	----	.21	----	2.20	1.14	T	1.72	.30	2.40	1.12	1.29
Wildersville	1.10	.80	1.36	.85	.40	----	1.03	2.22	1.75	2.23	.58

	JULY			NOVEMBER			
	7	8	9	14	15	16	17
Dyersburg	----	4.05	.65	T	2.00	1.20	.70
Kenton	3.38	----	----	.40	3.19	.60	----
Milan	.37	.81	1.11	.05	.70	.75	.55
Trenton	1.04	----	.36	.33	2.12	.93	----
Wildersville	1.10	1.02	----	.05	----	.70	----

(Table No. 5 Continued)

1910

	JANUARY			FEB.	
	4	5	6	27	28
Dyersburg	----	1.20	1.40	2.88	.21
Kenton	----	1.05	1.15	3.70	.05
Milan	.05	.50	1.15	1.73	.35
Trenton	----	1.98	1.00	3.55	----
Wildersville	2.40	----	----	.80	----

The heaviest storm during the time covered by the tables occurred from November 17th to 21st, 1906. The distribution was as follows:

TABLE NO. 6.

November	17	18	19	20	21
Dyersburg	2.00	4.50	.20	1.50	3.00
Kenton	4.42	2.03	.88	2.00	2.24
Milan	2.11	4.90	.30	1.50	2.55
Trenton	6.47	T	2.28	1.45	2.25
Wildersville	7.00	.50	.40	2.50	.60
Average	4.40	2.39	.81	1.79	1.53

Another very heavy rain occurred in December, 1902. The records from only three stations are available and are given below:

TABLE NO. 7.

December	14	15
Kenton	1.40	6.03
Trenton	1.36	4.90
Wildersville	1.50	4.96
Average	1.42	4.96

These two storms are the only ones in which 6 inches of rainfall in 48 hours was exceeded during the period for which we have records.

In the 12 years from 1897 to 1910 there have been 21 storms, during which an average rain of 2 inches or more fell in 24 hours, and three during which 4 inches or more fell in 48 hours, over the entire drainage area.

TABLE NO. 8.

The maximum 24-hour rainfalls recorded at the several Stations:

Dyersburg, November 18, 1906	4.50 inches
Kenton, December 15, 1902	6.03 inches
Milan, November 18, 1906	4.90 inches
Trenton, November 17, 1906	6.47 inches
Wildersville, November 17, 1906	7.00 inches

A table (No. 9) was compiled showing the number of rains of 2 inches or more in 24 hours that have occurred at Trenton, Tenn.:

TABLE NO. 9.

Excessive precipitation of 2 inches or more in 24 hours at Trenton, Tenn.:

1897—December 20	2.23	1903—March 6	2.00
1898—January 14	2.18	1903—July 31	2.00
1898—January 19	2.42	1903—December 19	2.50
1898—January 22	3.36	1904—September 3	2.20
1898—March 15	3.44	1904—December 26	2.50
1900—June 15	2.03	1904—December 27	2.60
1900—November 20	2.86	1905—November 29	4.70
1901—August 14	2.75	1906—November 17	6.47
1901—August 20	2.05	1906—November 19	2.28
1901—September 13	2.05	1906—November 21	2.25
1901—December 14	2.00	1907—May 6	3.00
1902—March 28	2.23	1909—February 14	2.20
1902—October 5	2.50	1909—April 13	2.40
1902—December 15	4.90	1909—November 15	2.12
1903—February 15	2.44		

Two inches or more fell on 29 days, 3 inches or more on 5 days, 4 inches or more on 3 days, and on one day 6.47 inches fell at Trenton.

DISCUSSION OF RUN-OFF.

On the North Fork of the Forked Deer and on the Rutherford Fork of the Obion River practically all of the run-off from heavy storms reaches the river bottoms within three to six hours after a rain. On the Middle Fork of the Forked Deer River, a somewhat longer time may be required in case of the larger branches. No gaugings of these streams have been made during flood flow, so that this class of data does not exist as a basis for making estimates. The best obtainable results may be secured by comparing these areas with others on which definite estimates of run-off have been made by assuming that a given percentage of the rainfall of heavy storms will pass off to the streams, and by estimating the amount of water stored in the bottoms after storms. On the bottoms of the North Fork, flood water gathers to a depth of three feet after exceptionally heavy rains. As the area of the bottoms is about 10 per cent. of the area of the entire watershed, it appears that 3 1-2 inches from the entire watershed has entered the bottoms, in addition to that which has flowed off through the channel This would indicate a run-off greater than any considered in this report. Before definite plans for the work are completed, careful gaugings of the various channels should be made to determine the rate of run-off.

Over a considerable part of the areas under consideration light rains falling on well-drained soil produce almost no run-off, all the water passing at once into the ground. The run-off during the winter will be greater than during the summer months, and more water will enter the bottoms after a storm which follows a season of wet weather than when such a storm occurs after a drouth. On the whole, however, it is probable that during rainfalls of two inches or more during twenty-four hours, from half to two-thirds of the total precipitation will pass into the streams within a few hours after it falls as rain. As a general precipitation of two inches or more over the entire area of the three streams occurs on the average twice each year, it appears from the above statements that to provide for a run-off of less than one inch in twenty-four hours in the outlet channels would not make the valley secure from overflow. As but fifteen hours will be required for the water to traverse the entire length of a channel provided for the valley of the North Fork, it is seen that the rate can not safely be reduced to any great extent for the entire area of a watershed of this size. More probably it should be raised for smaller areas within which more precipitous local storms may occur. To provide for less run-off would furnish some relief from the present overflowed conditions of the bottoms and would make possible the production of late corn and peas. It is doubtful, however, whether any less effective protection would represent as good an investment. It nearly always occurs that where a drainage project has been undertaken and the plans have been found to furnish insufficient relief, the people will make further investment to save that which was made in the first instance. However, if the work is not to be done thoroughly at first, the plans should be so prepared that further work can be done without losing the value of the first investment. It commonly occurs that where work must be reconstructed a considerable part of the original investment is wasted, so far as its value in lessening the cost of reconstruction is concerned.

DESCRIPTION OF STREAMS.

RUTHERFORD FORK OF THE OBION RIVER.

The Rutherford Fork of the Obion River rises in Carroll county and flows in a northwesterly direction across Gibson county to its junction with the Obion River about three miles north of Kenton. The watershed of the stream is approximately fifty miles long and from four to twelve miles wide, and has an area of about 370 square miles. The M. & O. R. R. follows the valley from Rutherford to its lower end. The L. & N. and I. C. Railroads cross the stream near Milan.

The watershed varies from gently rolling to hilly land. As a rule, the territory on the north side of the river is rougher than that on the south side. The river flows through a broad flat flood plain varying in width from 1-4 to 1 1-2 miles and averaging about one mile wide, the greater part being in timber and used for pasture. Sloughs occur on both sides of the river.

The lateral drainage is received through many small tributaries, the largest of these being near the upper end. Wolf Creek and Johns Creek are the most important tributaries.

From a point about four miles up stream from Rutherford nearly all the larger tributaries that enter from the north carry considerable sand, and as the river flows quite near the north edge of the valley the sand from many of these has reached the main channel and is filling it. The streams entering from the rolling country on the south carry but little sand.

Drainage Condition.

The channel of Rutherford Fork is very crooked, and, like the two others, is obstructed by logs, drift, and trees. As the river was in flood when the examination was made, a close inspection of the channel was not possible. It has a top width of 50 to 70 feet at the lower end, and is said to be 7 to 10 feet deep. The river overflows its banks and floods the bottoms after every hard rain. These floods frequently last several days and at times much longer. In its present condition the river is totally inadequate to remove the flood water.

NORTH FORK OF FORKED DEER RIVER.

The North Fork of the Forked Deer River rises in the southeastern part of Gibson county, Tennessee, near Sitka Station, and flows in a general northwesterly direction to a point on the west line of Gibson county, where it unites with the Middle Fork. The watershed of the stream is approximately 30 miles long, from 5 to 8 miles wide, and covers about 270 square miles. The L. & N. and I. C. Railroads cross the headwaters, and the M. & O. R. R. traverses the valley at Trenton. There are approximately 18,000 acres of overflowed land in the valley.

The watershed varies from rolling to very hilly land. The river flows through a broad level flood plain approximately 3-8 of a mile wide at the L. & N. R. R., widening to about 1 1-4 miles at the mouth. It is said to have an average width of one mile between these two points. The valley has a varying grade, falling about 1 1-2 feet per mile at the lower end and about 4 feet per mile at the upper end. The channel has a top width through the lower half of its course of 60 to 70 feet and an average depth of not more than 5 feet.

The greater part of the flood plain is timber land, though in a few places the bottoms are being cultivated. There are numerous depressions and secondary channels through the length of the valley. The lateral drainage is received through small tributaries or branches that enter the valley at frequent intervals. Many of these do not reach the river, but disappear when they reach the bottoms, becoming sloughs and ponds. A number of them carry considerable sand, but in most cases this is deposited before it reaches the rivers. The greater part of the streams that carry sand enter the bottoms above Trenton. The floods of this stream are similar to those on the Rutherford Fork. During extreme storm periods water stands over the bottoms three feet deep or more, requiring weeks to pass off.

THE MIDDLE FORK OF THE FORKED DEER RIVER.

The Middle Fork of the Forked Deer River rises in Henderson County and flows westerly to the west lines of Gibson County, where it unites with the North Fork. The drainage basin is about 55 miles long, 10 to 16 miles wide, and has an area of about 700 square miles. It is crossed by three railroads; the M. & O., the I. C., and the L. & N. The headwaters of the stream flow through very hilly country, but toward the west the land is more rolling and the hills have steeper slopes. Except at the upper end, the flat river bottom averages about two miles wide. A number of the larger tributaries also have broad flat bottoms, the largest about a mile wide, which will require drainage for their reclamation. Only a few of the branches seem to carry sand in large quantities. Apparently the control of sand deposits will not be a matter of so serious concern on this stream as on the other two. There is much erosion in the hills, but this occurs mostly in a fine silt loam, which will probably remain in suspension in the water until it reaches the outlet.

The channel of the Middle Fork is similar to the other streams in being crooked and obstructed by debris, and in being wholly inadequate for the drainage of the watershed. During flood flow several times as much water passes through the river bottom outside of the channel as is carried within its banks.

If the improvement of the Middle Fork were to be secured by carrying the flood waters in a large channel below the ground surface, it would represent a slightly better prospect for drainage than the other two streams; for while there is approximately twice as much land to be redeemed on the Middle Fork as on the North Fork, the drainage area is more than two and a half times as great, and therefore much larger channels would be required. However, if a combined system of ditches and floodway is used the cost of sonstruction will not increase in proportion to the amount of water to be carried, and the improvement of this stream can be carried out at a smaller cost per acre to the benefited land than that on either of the other streams. An estimate of this cost would not be justified without a survey to determine the fall obtainable throughout the river bottom, and other conditions affecting the plan.

DRAINAGE CONDITIONS.

The channels in their present condition will carry but a small part of the water which reaches them during floods. They are very crooked, and in bad order—full of trees, logs, stumps, and drifts that extend entirely across the channel. In times of flood a large part of the water flows over the river bottom outside the channel. The rivers overflow their banks in this manner during every heavy rain, these floods being generally of short duration; but there are occasional periods when the lowlands are covered for a week or more at a time. The overflows occur most often during the Winter and Spring. The frequent floods prevent the land from being cultivated and greatly reduce its value for pasture. Some of the larger tributaries frequently flood their valleys and do serious damage, but it would seem probable that the construction of a main channel would materially lessen the damage on these streams. The rivers flow through broad flat bottoms from less than half a mile to more than two miles wide. These are so flat that the overflow water of heavy rains extends entirely across the valley. The river channels meander back and forth across these flat valleys on their courses toward the West.

SOIL EROSION AND THE SILTING OF CHANNELS.

The erosion of soils on hillsides, while of frequent occurrence in the watershed of these streams, is not so serious a menace there as on streams farther south and east. In the west half of the proposed district the hills are low, and there is little evidence of extensive soil wash. Probably the most serious situation is along the creeks at the east ends of the valleys. Here roadside ditches have washed out, forming gullies perhaps 20 feet deep, which carry sand and silt from the hillsides and from the sides of the gulley, depositing it on the bottom lands below. Some of these bottoms have been filled in this manner to a depth of five feet during recent years.

Hillside washing is taking place to a serious extent at several points, with a consequent deposition of sand and silt on the lower land. The cutting consists of the erosion of abandoned fields, or the formation of large gullies where roadside ditches once were located. The deposits of sand and silt have as yet reached the river channel in but few places. Where erosion takes place in abandoned fields, the material usually remains in the bottoms of wooded gullies or channels, frequently filling them entirely. Where roadside ditches have enlarged into gullies the sand is commonly laid down on the bottom lands adjoining. In the few cases where sand has been carried into the river channel usually it has been dropped very near the point where it entered the channel, partly filling it and forming a sand bar. A large part of the silt held in suspension in the water either passes through the entire length of the channel or is deposited on the bottom lands from the overflow water. The danger of sand deposits is most serious on the Rutherford Fork and is least on the Middle Fork of the Forked Deer River. On the latter stream there are but few tributaries which carry sand to the main channel; for while hillside washing is more serious here than on the North Fork, the soil contains very little sand.

THE CONTROL OF SOIL EROSION AND DEPOSITS.

The problem of controlling soil erosion is not a very difficult one on these, as compared with many streams, but the success of a drainage system depends to a considerable extent upon this question being properly worked out. It is safe to assume that while a large amount of silt and clay may enter the channel, be carried through its entire course, and be discharged at its lower end, any sand which enters the upper half of the canals will remain and tend to fill them up. At present but little sand reaches the main channels of any of these streams. It is stated to be the intention of the landowners, however, upon construction of the main canals, to dig lateral ditches into them for the purpose of carrying away the sand which now is deposited upon the surface of the farm lands. This intention is based upon the supposition that the water in the canals would have sufficient velocity to carry to the outlet any sand which would reach them. It is probable that a limited amount of sand would be rolled along the bottom of the ditches until finally it would reach the outlets, but in the meantime parts of the ditches above might become almost entirely filled. In some instances in Mississippi where similar conditions prevailed, except that the erosion was greater, channels constructed in this manner not only have been entirely filled, but the water loaded with sand flowing between the waste banks of the ditches has built up the ditch beds to a higher elevation than the surrounding land.

For the successful operation of this drainage system all large deposits of sand must be prevented from reaching the channels and provisions to secure this result should be essential parts of the drainage plan. Fortunately there are but a limited number of points where serious erosion occurs in soil containing a large proportion of sand, and these can be controlled without adding very greatly to the cost of the system. In the greater number of these places, while the deposits are gradually extending across the river bottoms, they have not yet reached the location of the main channel. In these cases there is no iminent need for protection, except to establish the policy that no ditching shall be done which will result in depositing sand in the channel. As lateral drainage will be necessary to complete the reclamation begun by the main canal, it will soon be necessary to find some other means of control. The following methods are suggested as offering some advantages. A complete drainage plan should include methods of control in each case where the conditions require attention.

Control by Collecting Ditches.

In many cases where sand deposits have not yet extended very far into the bottom, one of the simplest methods of control would be to allow the sand-bearing hill stream to spread out over the bottom as at present until the sand is deposited, and then to pick up the water in a collecting ditch located around the margin of the overflowed tract, carrying it from thence into the main channel. This would prevent the overflow of any land except that necessary for receiving sand deposits. If too much sand was being deposited on one piece of land for farming purposes, the hill stream could be led from one part of the field to another, still being controlled in the same manner.

Collecting Basins.

It is wholly practicable to construct a levee around a tract of land at the outlet of a hill stream, forming a settling basin in which the water of the hill stream will deposit its sand and much of its silt. The water may then be let off through a wooden or concrete flume and carried to the main channel. This method has been practiced successfully in Illinois, and its use on a large scale is being planned in Missouri and Mississippi. In the case in question enough silt would be deposited with the sand to make a good farming soil, and frequently it will be possible to use as a settling basin a slough or tract of lowland which will be benefited by sand deposits.

THE PREVENTION OF EROSION.

The remedies suggested above, while perhaps sufficient for years to come, are at best but temporary expedients, and the final solution of the problem must lie in preventing erosion in the hills. In many of the localities this proposition would truly be a formidable one, but here, where hillside washing is already to a considerable extent under control, the prevention of further erosion is entirely practicable, and can be attained at an expense small in comparison with the benefits to be received. Such preventive work would consist in stopping the formation of deep gullies, especially along roadsides, and in preventing the further erosion of abandoned fields. A large part of the sand now being carried onto bottom lands is washed from large gullies which have formed along roadsides. Further washing could be prevented in most instances by placing properly constructed brush dams at frequent intervals along the gullies; checking the velocity of storm water, and causing the gullies to fill to a higher level; thus covering some of the sand strata which erode most easily. In some places more substantial timber dams may be necessary to supplant those built of brush. In constructing future road ditches they should be carried down the hillsides by gentle slopes to prevent further soil erosion. If necessary, the laws should be amended so as to give the road authorities the right to pass over private holdings in constructing ditches of this character. Doubtless in the present instance landowners would willingly allow such constructions on their lands. It is probable that the most satisfactory results from such ditches will be secured only when locations are made after suitable surveys.

The control of erosion in fields is reaching such a point that if fields now washing badly are prevented from further deterioration, those which have not begun to erode will be prevented by the landowners from doing so, and trouble from this source will be ended. In many instances further washing can be prevented by digging hillside ditches above the eroded areas, leading the water away by gentle slopes, so that no further cutting will take place. In other instances gullies may be filled by brush dams. A general practice should be adopted of plowing furrows along the hillsides rather than up and down the slopes; and hillside ditches should be dug in a similar manner to catch rain water before it has gained sufficient volume to form gullies, leading it along the slopes of the hills to the points of outlet. In many places where fields are now washing badly the sand is lodging in wooded gullies further down, and at its present rate of progress will not reach the main stream channels for several years.

In short, the problem of hillside erosion and of sand deposits, while demanding careful and effective handling in the preparation of a drainage plan, does not constitute a serious menace to the success of the district.

THE ENLARGING OF CHANNELS BY EROSION.

It has been assumed in some instances that small channels constructed through these bottoms would quickly enlarge by erosion until they would be of sufficient size to accommodate the water of extreme floods. This opinion is based to a considerable extent upon observation of the erosion which frequently takes place in short cut-offs, or in ditches entering the river bottoms with a heavier fall than exists through the bottoms. In the case of cut-offs there is usually a drop-off curve at the lower end, where the water flows very swiftly as compared with the main channel. The channel enlarges along the line of this drop-off curve, which works back up the channel to the upper end of the cut-off. To expect that a long straight channel of uniform cross section and velocity will enlarge in a similar manner in the course of a few years is not justified by any information we have on the subject. In fact it is more probable that the channel will fail to maintain itself, and will tend to fill with sand, unless precautions are taken to prevent this.

WHAT CONSTITUTES RECLAMATION.

The reclamation of these river bottoms may be more or less complete, depending upon the amount of money invested in the work. With a sufficient investment the bottom lands may be completely protected from all overflow, even in case of the most severe storm; while with a smaller expenditure the relief will be proportionately less. In order to get the largest return for the money invested, it is necessary to use good judgment in deciding what degree of reclamation shall be undertaken. Under the present conditions of development in this region it would probably be unwise to plan drainage which would protect the land from those rare storms which occur not oftener than once in ten years, and doubtless many of the landowners would prefer to risk the loss of a crop once in three to five years rather than to increase largely the cost of the improvement for the purpose of insuring against such loss. However, land on which a crop would be lost oftener than once in three to five years, or on which but a limited variety of crops could be raised, can not be said to be effectively reclaimed, and would not be profitable for farming purposes. If the bottoms should be overflowed nearly every winter, the production of wheat, oats, and clover would be impossible, and if overflows are common in May the raising of cotton would be uncertain. The remaining crops of corn, peas, and pasturage would furnish an income from the land, but its being limited to these crops would largely reduce its practical value. Moreover, if large areas are overflowed in May, it will frequently be impossible to put the land in cultivation in time to produce a corn crop where one farm has a large area of this class of land. Where the bottom is in pasture, and is overflowed by the muddy waters, it becomes useless for this purpose for some weeks, or until the next heavy rain. Hay meadows are likewise seriously injured by overflows during the growing season. It seems, therefore, that a profitable degree of reclamation would be that which would secure freedom from overflow during years of ordinarily heavy rainfall, so that crops would be lost, or serious damage sustained, not oftener than about once in three to five years. As the loss of a single crop would amount to more than the cost of the reclamation, it would seem that any protection less than this would be poor economy. Even this class of improvement should be planned so that it may be enlarged at any time in the future.

If an improvement were planned to be sufficient for about four years out of five, it might occur that there would be no overflows for ten years or more, or overflows might occur for two or three years in succession; because a number of unusually wet years or a number of unusually dry years may follow each other in succession. Only the general tendency can be determined beforehand. In suggesting plans for the work, the degree of reclamation outlined above has been followed, except where noted otherwise.

PLAN OF IMPROVEMENT.

A plan for the improvement of the North Fork of the Forked Deer River already has been presented. It provides for a channel extending through the river bottom for a distance of about 27 miles. This proposed channel, which would remove about one-fourth of an inch of water from the entire watershed in 24 hours, would have about one-third or one-fourth the capacity necessary to furnish relief from overflow in years of ordinary rainfall. The expectation that it would enlarge by erosion probably would not be fulfilled to any important degree. As the new channel is planned to cross the old one in various places, the latter would fill with silt at each of these crossings, soon becoming useless for carrying water. If the landowners should carry out their present intention of ditching sand-bearing tributaries into the main channel, it would tend to fill with sand, as but a small part of that which would enter it would reach the outlet.

Unless careful stream gauging extending over periods of heavy rainfall should indicate otherwise, it appears that a channel for the relief of the North Fork should have sufficient capacity for removing three-fourths to one inch in depth of water from the entire drainage area in 24 hours in order to secure freedom from ordinary overflows. It does not necessarily follow that reasonable protection will cost three or four times as much as the work which has been proposed. A larger capacity may be secured at relatively less expense, if a single large channel is constructed, while it is very probable that on the lower part of the North Fork a large portion of the flood water can be carried on the surface of the ground, confined between levees perhaps 400 feet apart. The levees would be formed by the waste banks of smaller ditches which would carry the local drainage water outside the floodway and below the surface of the ground. A small dredge ditch would be required within the floodway to carry the low water flow. The use of such a floodway through the lower valley of the North Fork would probably result in considerable saving over the cost of a very large channel.

Where a floodway is to be used, its capacity may be greatly increased by leaving a wider space between the controlling levees, the cost of purchasing and clearing the additional land being the only additional expense required for such an enlargement. In designing this method of improvement, therefore, it would be desirable to plan a floodway in the first instance to have sufficient capacity for the complete reclamation of land tributary to it.

An estimate of the cost of reclaiming the bottom lands of the North Fork should be based upon a careful survey, such as is outlined elsewhere in this report. It seems probable, however, that reasonably complete reclamation, such as would prevent overflows oftener than once in three to five years may be secured for $10 to $15 per acre. It would be a mistake to plan an improvement so completely inadequate that but little benefit would result from its construction.

BENEFITS.

The land which it is proposed to reclaim is useless for cultivation in its present condition, and has but a limited value as meadow and pasture land. The soil is very fertile, and if properly drained and protected from overflow would be the most valuable in this territory for raising corn, cotton, wheat, and grass. The construction of drainage improvements costing from $10 to $18 per acre would make land which now sells for $10 to $20 worth $50 to $75 per acre, and would give it a rental value of not less than $5 per acre. The increased rental value of the land would pay the cost of the improvement, including interest, in five years or less. In addition to increasing the value of the land, the drainage improvement would benefit the health of the community by removing the breeding places of the mosquito, and would probably result in completely eliminating malaria from this region. There is sufficient timber on most of the bottom land to pay for clearing it and putting it into cultivation.

It is fully believed that while complete drainage may cost somewhat more than has been anticipated, it will be a most profitable investment. Where it is considered that the loss of a single crop due to overflow would amount to more than the whole cost of the improvement, it is seen that there is small economy in constructing an inadequate system.

SURVEY.

A survey of the North Fork of the Forked Deer River has been made by H. P. Farrar, C. E., from the L. & N. bridge to its mouth. This survey gives much valuable data. The map shows the location of the channel and of many of the tributaries, and has in addition elevations marked on it at various points. Before it is decided to construct the improved channel, further surveys of this and other streams should be made as follows:

A survey to determine the boundaries of the watersheds may be necessary. A compass and stadia traverse line will be sufficient for this work, as the traverse can be tied to the main traverse of the river at intervals of 5 or 6 miles.

A hydrographic survey of the streams should be made, and as much data as possible obtained as to the amount of run-off and the duration of floods. There seem to be few desirable places to make flood gaugings, as nearly all the grades or levees across the river bottom are overtopped during the floods. It probably will be best to select several small tributaries with good channels, and to make gaugings on these. There are several streams suitable for this purpose. The areas of their watersheds could be determined readily, and with the rate of run-off from them worked out, that from the entire watershed could be estimated quite closely.

A stadia traverse should be made on both sides of the valleys to determine the areas of the flooded lands. Levels should be run on this line at the same time, and probably it would be best to carry three or four two-foot contours along each side. This would accurately indicate the amount of land benefiited and the location of the bottom lands. This survey should also locate all property lines on the bottoms and all natural channels not located on the existing maps. The survey should be referenced by means of permanent points. Permanent bench marks should also be set at suitable intervals.

Sufficient topography should be secured to enable a map of the valley to be made, and to determine the best location for the ditches. This should include the locations, dimensions, and condition of all tributaries to the river, and should be sufficient for locating the improved channel and the necessary settling basins for sand and silt. Lines of cross levels should be run across the valley at approximate half-mile intervals. These, with the hydrographic survey, will give all the topographic data which will be of value for drainage purposes. Five-foot contours would be practically useless, as there is seldom a difference of elevation of five feet in the entire width of the valley.

Careful studies should be made of erosion and silting of streams, and soil borings should be made along the lines of the canals to determine the presence of sand strata which would effect construction and maintenance. As the improvements must be paid for by assessments on the land benefited, the boundaries of the various tracts should be located. The final location of the main channels should be made after the maps are completed which show the topographic and other features.

RECOMMENDATIONS.

The object of this investigation was to determine the drainage conditions on the three streams discussed in this report, and to recommend means for reclaiming the adjoining bottom lands. The following conclusions were reached as a result of the examination:

The overflowed lands along these streams are susceptible of complete reclamation at a cost which is reasonable in comparison with the results which will be received. The Rutherford Fork of the Obion River offers the least favorable prospects, while the Middle Fork of the Forked Deer River can be reclaimed for the least expenditure per acre.

It would be a mistake to construct a wholly inadequate system of drainage in the hope that the channels will enlarge themselves by erosion.

By the use of floodways carrying the greater part of the water through the valleys above the surface of the ground and between levees, the cost of reclamation on the Middle Fork, and perhaps on the other streams, can probably be much reduced over the cost of canals large enough to serve the purpose.

If sand from the hills is allowed to enter the drainage channels they will deterioate rapidly, and a large expense for re-dredging may be frequently necessary. With proper care and good planning the sand can be prevented from reaching the main channels.

Until reliable observations of run-off are secured, the planning of the drainage canals will be attended by much uncertainty.

A careful drainage survey should precede construction on all of the streams.

It would be desirable to have the State Drainage Law examined by an attorney who is an authority on bond issues, to determine whether the law as it stands will be effective for carrying out the improvement.

3-C

STATE OF TENNESSEE
STATE GEOLOGICAL SURVEY
GEO. H. ASHLEY, STATE GEOLOGIST

Drainage Law of Tennessee

(Senate Bill No. 229)

EXTRACT FROM ACTS OF TENNESSEE, 1909,
CHAPTER 185

EXTRACT (C) FROM BULLETIN No. 3, DRAINAGE
RECLAMATION OF TENNESSEE, 1910.

NASHVILLE, TENNESSEE
1910

CONTENTS

SECTION 1. To provide for establishment of levee and drainage districts.. 49
SECTION 2. Petition and bond required ... 49
SECTION 3. Engineer to be appointed ... 50
Report to be made ... 50
Engineer may be recalled ... 51
Location of drains and ditches ... 51
Crossing railroads ... 51
Help may be employed ... 51
SECTION 4. County Court may approve or reject plans ... 51
Writs to be served on owners not petitioners... 52
Publication—when required ... 52
Hearing may be postponed ... 53
SECTION 5. Claims for damages ... 53
SECTION 6. Jurisdiction of the County Court ... 53
Jury of view ... 54
SECTION 7. To file reports with clerk ... 54
SECTION 8. Decision of County Court ... 54
Appeals ... 55
Circuit Court proceedings ... 55
May prorate costs ... 56
SECTION 9. Damages—by whom to be paid ... 56
Power of condemnation ... 56
SECTION 10. May require new survey and estimates of cost... 56
SECTION 11. Commissioners and qualifications ... 57
Duties ... 57
Apportionment of cost of construction ... 57
Basis of assessment ... 58
Notice of assessments ... 58
Additional assessment may be made ... 59
New report may be ordered ... 59
SECTION 12. Assessments—how collected ... 59
SECTION 13. Appeals ... 59
SECTION 14. Counsel may be employed ... 59
SECTION 15. Drainage record ... 59
SECTION 16. Fees ... 60
SECTION 17. New apportionment made—when ... 60
SECTION 18. Directors—qualifications and terms ... 60
Board of Directors ... 60
Vacancies and removals for cause ... 60
Organization ... 61
Bond of treasurer ... 61
SECTION 19. Contract may be made—when ... 61
Notice for four weeks ... 61
Deposits from bidder ... 62
Bond of contractor ... 62

Section 20. Engineer to be employed 62
Removal for cause 62
Monthly estimates of work done 62
Warrants—how paid 63
Section 21. Assessments against railroads 63
How enforced 63
Section 22. Bridges 63
Section 23. Rights of landowners assessed 64
Section 24. Assessments—how collected 64
Section 25. Character of work—how determined 64
Section 26. Sub-districts may be established. 64
Section 27. Drainage bonds may be issued 65
Proceeds of issue 65
New apportionment and additional bonds may be issued. 65
Duties of Clerk and Trustee 65
Terms of bonds 66
How signed 66
For what district issued 66
How payable 66
Denominations 66
Section 28. Warrants may be issued—when. 66
Section 29. When district is in more than one county 67
Duplicate reports of engineers 67
Proceedings 67
Viewers 67
Section 30. Commissioners 68
Section 31. Board of Directors. 68
Organization 69
Bond of treasurer 69
Section 32. Drainage assessment book 69
Section 33. Assessments become liens upon lands. 70
Delinquent lists 70
Prima facie evidence 70
Assessment liens—how enforced 70
Sale of lands may be ordered 70
Writ of possession may be given purchaser 71
Time and terms of redemption 71
Attorney's fees 71
Decree of redemption may be had. 71
Exceptions 71
Section 34. Distress warrants may be issued. 71
Section 35. Petitions may be signed by attorney or agent of petitioner. 72
Section 36. Salaries and expenses 72
Compensation of trustees and clerks 72
Expenses of directors 72
Section 37. Contractors to forfeit deposits—when. 73
Section 38. Mutual agreement districts may be established 73
Section 39. Preliminary expenses—how paid 73
Section 40. This act not to apply to Reelfoot Lake. 74

DRAINAGE LAW OF TENNESSEE

CHAPTER 185.

(Acts of Tennessee, 1909.)

SENATE BILL NO. 229. BY MESSRS. SENTER AND WARD.

AN ACT to provide for the establishment of levee and drainage districts for the purpose of the draining and reclamation of the wet and swamp lands and lands subject to overflow in the State, and prescribing the method for so doing, and providing for the assessment and collection of the costs and expenses of such improvements, and the manner of obtaining the means or funds therefor.

To provide for establishment of levee and drainage districts.

SECTION 1. *Be it enacted by the General Assembly of the State of Tennessee,* That the County Court of any county in this State is hereby vested with the jurisdiction, power, and authority at any regular, special, or adjourned session to establish a drainage district or districts, and to locate and establish levees, and cause to be constructed, as hereinafter provided, any levee, ditch, drain, or water course, or to straighten, widen, deepen, or change any natural water course in such county, or provide for the same being done whenever the same will be of public utility or conducive to the public health or welfare, and as hereby provided. The court here vested with this jurisdiction and authority is the County Court held and presided over by the County Judge or Chairman, and not the Quarterly County Court, and all references in this Act to the County Court is to the court so held by the County Judge or Chairman, unless otherwise stated.

Petition and bond required.

SEC. 2. *Be it further enacted,* That before any County Court shall establish a drainage or levee district, or any levee, ditch, drain, or water-course improvement, as provided for in this Act, a petition, signed by one or more persons owning land that will be affected by or liable to be assessed for the expenses of the proposed improvement, shall be filed in the office of the County Court Clerk of the county in which the improvement is expected to be made, setting forth that any body or district of land in such county, described by metes and bounds or otherwise, so as to convey an intelligible description of such lands, is subject to overflow, or too wet for profitable cultivation, and that the public health or welfare will be promoted by draining, ditching, or leveeing the same, or by changing a natural water course, or by in part changing such water course by cutting across bends of the same and shortening its length, or by cleaning out its natural bed or deepening or enlarging such bed, or by giving such water course a new outlet, or any or all of these and similar things pertaining to the proposed improvement, and setting forth in said petition as near as may be the starting point, route, and terminus, and lateral branches, if with proper prayer for purpose desired; and there shall be filed with said petition a bond, with good security, in such penal sum as the County Clerk may deem adequate, to be approved by him, and conditioned for the payment of all preliminary expenses till refunded, and of all costs and expenses incurred in the proceedings in case the County Court does not grant the prayer of the petition, or the petition is dismissed for any cause. The County Court may at any time deemed proper order said bonds increased in penalty or in sufficiency, and make all necessary orders to this end.

Engineer to be appointed.

SEC. 3. *Be it further enacted,* That after such petition has been so filed and bond taken and approved, the County Court shall, at the first session thereafter, regular, special, or adjourned (and may at a later session), appoint a disinterested and competent engineer and have placed in his hands a copy of said petition, and he shall proceed to examine the lands described in said petition, and any other lands that would be benefited by said improvement, or necessary in carrying out such improvement, and survey and locate such drain or drains, ditch or ditches, levee or levees, improvement or improvements, as may be practicable to carry out the purposes of the petition, and which will be of public benefit or utility or conducive to the public health or welfare. He shall make return of and file his proceedings with the County Clerk, which returns shall set forth the starting point, the route, the terminus or termini of the ditch or ditches, drain or drains, levee or levees, or other improvements, such as the straightening or shortening of water courses, cleaning out the beds thereof, etc., together with a plat and profile showing the ditches, drains, or other im-

Report to be made.

provements, and the course and length of the same, approximately, through each tract of land as far as may be practicable, and the total length and the course and the elevation, as near as may be, of all lakes, ponds, and deep depressions in said district, and the fall obtainable across said district, and the boundary of the proposed district, and the description of each tract of land therein, as shown by the tax books, and the names of the owners thereof, as shown by the tax books, together with the probable cost of the improvement, and such other facts and recommendations as he may deem material.

Engineer may be recalled.

The court may at any time recall the appointment of any engineer made under the provisions of this Act, if deemed advisable to do so, and appoint another to act in his place.

Location of drains and ditches.

That the ditches and drains herein provided for shall be surveyed and located along the general course of the natural streams and water courses, or in the general course of the natural drainage of the lands of said district, unless there should be some special and good reason why the natural course should be departed from to secure a new and better outlet, or for any other good reason, and having due regard to the straightening and shortening of such natural streams, water courses, and course of natural drainage.

Crossing Railroads.

Whenever such ditch or drain crosses any railroad track or right of way, it shall be located at the place of the natural waterway across said right of way, unless said railroad company should have provided another place in the construction of its roadbed for flow of the water, or unless another place for so crossing its right of way shall be agreed upon by said railroad company; and if located at the place provided by or agreed upon by the railroad company, such company shall be estopped from afterwards objecting to such location on the ground that it is not the place of the natural waterway.

Help may be employed.

The engineer may employ necessary help—such as axmen, rodmen, etc.—returning an itemized expense account.

County Court may approve or reject plans.

SEC. 4. *Be it further enacted,* That upon the filing of the return of the engineer, the County Court shall examine the return; and if the plan seems to be expedient, and meets the approval of the court, it shall order the County Clerk to cause notice to be given, as hereinafter provided; but if it does not appear to be expedient, and is not approved, the court is hereby authorized to direct said engineer, or another engineer selected by it, to prepare another plan. If the court should deem the proposed improvement inexpedient or inadvisable, after an examination of the return of the engineer, or after a second or further return, it may dismiss the petition and proceedings, and, in that event, it shall adjudge all costs and expenses incurred against the petitioners and the sureties on said bond. When the plan, if any, shall have finally met the approval of the court, it shall order the County Clerk to issue a summons, or writ, to the Sheriff of the proper county, said writs to run in the name of the State, commanding the Sheriff to summons the persons named in said writ to appear before the court on the day set by it for the hearing of said petition. Said writ or summons shall name therein to be served the owners of all the tracts or lots of land not petitioners, within the proposed levee, improvement, or drainage district, as shown by the tax books of the county, or by affidavit filed, and upon the persons in actual occupancy of the lands or lots, and also upon any lien holder or incumbrances of any land in the proposed district, as shown by the county records, and shall notify them of pendency of said petition and the prayer thereof; but no copy of the petition shall accompany the writ.

Writs to be served on owners not petitioners.

Said writ shall be served at least twenty days before the time set for the hearing of the matter of said petition; but said writ shall not be issued for or served upon any of the persons hereinbefore described who shall file with the Clerk a statement in writing, signed by said party, entering his appearance at said hearing and waiving any additional notice, or the service of the writ may be acknowledged. In case any such owner, lien holder, or incumbrancer is a nonresident of the State, or his name or residence can not be ascertained after diligent inquiry, and these facts are made to appear by affidavit filed, then publication shall be made for such party for two consecutive weeks in some newspaper of the county where the proceeding is pending notifying such party or parties of the pendency and prayer of said petition, and to appear at the time set for the hearing thereof, the last publication to be at least twenty days before the time set for such hearing. Proof of such publication may be made

Publication—when required.

as now provided by law in Chancery cases, and who are actual owners, or such lien holder or incumbrancer, may be made to appear to the Clerk by the affidavit of any person acquainted with the facts or by the averments of the petition if sworn to.

Hearing may be postponed.

If at the time set for the hearing it shall appear to the court that any person entitled to notice as herein provided has not had such notice, the hearing shall be adjourned till such person can be given the required notice, and the court shall not lose jurisdiction of the subject-matter, or of the person already properly notified, by such adjournment or postponement. The persons concerned may appear and be heard without formally answering such petition in writing.

Claims for damages.

SEC. 5. *Be it further enacted,* That any person claiming damages as compensation for or on account of the construction of such improvement shall file such claim in the office of the County Clerk at least five days prior to the day on which the petition has been set for hearing, and on failure to file such claim at the time specified shall be held to have waived his rights thereto; *provided,* if such person be an infant or a *non compos mentis,* and without regular guardian, or such guardian has not been notified of the proceeding as herein provided for notice, and the facts are made to appear by affidavit, the court shall appoint a guardian ad litem for such person, who may file such claim for damages, if deemed proper for the person so under disability, within the time above allowed or within five days after so appointed.

Jurisdiction of the County Court.

SEC. 6. *Be it further enacted,* That the County Court, upon the hearing of said petition at the time set for hearing, or at the time to which the matter has been adjourned, or continued, shall proceed to determine the sufficiency of the petition in form and manner, which petition may be amended at any time, as to form and substance, before final action thereon; and if the court should find that such levee or drainage or improvement district would not be for the public benefit or utility, or conducive to the public health or welfare, it shall dismiss the proceedings; but if the court should find such improvement conducive to the public health or welfare, or to the public benefit or utility, it shall determine and adjudge the necessity therefor of such levee or drainage district; and if no claim for damages has been filed, as provided in Section 5 of this Act, the court may, if deemed advisable, locate and establish said district, or may refuse to establish the same, as the court may deem best; and at such hearing the court may order said engineer, or a new engineer appointed by it, if deemed advisable, to make further examination and report to the court as to said improvement, in which event the hearing shall be continued till the filing of such further report. If any claims for damages have been filed, as provided in Section 5 of this Act, the court shall not establish such district till viewers have been appointed and have reported, and the court shall proceed to appoint three viewers to assess such damages, who shall be disinterested freeholders of the county, and not related to any party interested in the proposed improvement, nor themselves interested in a like improvement, and the engineer appointed by the County Court as aforesaid shall accompany said viewers and furnish such information as may be called for by them concerning the survey of said improvement.

Jury of view.

To file reports with Clerk.

SEC. 7. *Be it further enacted,* That the viewers appointed to assess damages, after being duly sworn to act impartially and faithfully to the best of their ability, shall proceed to view the premises and determine and fix the amount of damages to which each claimant is entitled, and file reports in writing with the County Clerk showing the amount of damages each claimant would be entitled to because of the establishment of the proposed improvement. The report of the viewers shall be filed as soon as practicable; and if any of them fails or refuses to act, for any reason, or they do not proceed to act with promptness, the court may appoint others as viewers in the place of any or all of them. In estimating the damages, the viewers shall give the value of the land proposed to be taken without deduction, but incidental benefits which may result to the owner by reason of the proposed improvement may be taken into consideration in estimating the incidental damages.

Decision of County Court.

SEC. 8. *Be it further enacted,* That after the filing of the reports of the viewers, the court shall consider the amount of damages awarded in deciding whether such levee or drainage district should be established; and if in its judgment the probable cost of construction is not a greater burden than should be properly borne by the land benefited by the improvement, and the improvement is conducive to the public health or welfare, or to the public benefit or utility, then the court shall locate and establish such drainage or levee district by proper order or judgment to be entered of record, and the court shall thereupon proceed to determine the amount of damages sustained by each claimant, and may hear evidence in respect thereto, and may increase or diminish the amount awarded by the viewers, as may seem just and right. **Appeals.** Any party aggrieved may appeal from the decision of the court in establishing, or refusing to establish, the improvement district, or its decision in the allowance of damages, such appeal being to the Circuit Court, and any party so desiring to appeal shall have the right to have the benefit of such appeal at any time within ten days after such decision is made, without formally praying an appeal, by filing with the Clerk of the County Court a notice of such appeal, at the same time filing with him a bond, to be approved by said Clerk in such sum as he may deem adequate, and conditioned to pay all costs and expenses of the appeal, unless the finding of the Circuit Court shall be more favorable to the appellant or appellants than the finding or decision of the County Court.

Circuit Court proceedings, The Circuit Court shall hear any such appeal *de novo;* and if the appeal be from the amount of damages allowed by the County Court, the amount ascertained and fixed by the Circuit Court shall be entered of record, but no judgment shall be entered therefor. The amount thus ascertained shall be certified by the Clerk of the Circuit Court to the County Court, which court shall thereafter proceed as if such amount had been by it allowed the claimant as damages. If the appeal is from the action of the County Court in establishing, or refusing to establish, the drainage or levee district, the Circuit Court shall enter such order as it may deem just and proper in the premises, and the Clerk of said court shall certify the same to the County Court, which shall proceed thereafter in the matter in accordance with the order of the Circuit Court. In the Circuit Court in such cases the cases shall be docketed with the appellant or appellants as plaintiffs and the adversary parties as defendants, and where there are several appellants on questions of damages, the Circuit Court may consolidate the causes and hear or try them together, if practicable, making proper findings or orders as to each; and in such appeals from orders of the County Court made at the same session where there are several appellants, at their request only one transcript shall be made out by the County Court Clerk.

May pro rate costs.

On such appeals it shall rest in the discretion of the Circuit Court how the costs shall be adjudged and distributed among the litigants; and the trial in that court shall be with or without a jury, as the court may deem the right of the parties to be under the particular issues to be tried, the right to a jury being accorded wherever the parties have such right under the law of the land.

Damages—by whom to be paid.

SEC. 9. *Be it further enacted,* That after the amount of damages due any claimant or claimants shall have been finally ascertained and fixed by the County Court, the amount of all such damages shall by said court be required to be paid, in the first instance, by the parties benefited by said levee or drainage district, or be secured, to be paid upon such terms and conditions as the County Court may deem just and proper; and after said damages have been paid, or secured, as aforesaid, the County Court shall enter a proper order of condemnation showing all such lands are appropriated and belong to such drainage or levee district for all its necessary purposes. In establishing any such levee or drainage district, all necessary lands may be appropriated as herein provided, and a right of way as much as two hundred (200) feet wide may be so appropriated, if deemed necessary, for the situs and location of any ditch or drain, or for the location of a new route or channel for any natural water course for the whole way or parts of the way of its course; and the natural bed of any water course in such district may, in so far as the same may be utilized and necessary, be so appropriated, to the end that such bed or channel may be cleaned out, deepened, or widened; but the provision in this section as to the width of such right of way shall not prevent the County Court from ordering appropriated such other lands as may be deemed necessary for the purposes of such improvement district under the provisions of this Act.

Power of condemnation.

May require new survey and est'mats of cost,

SEC. 10. *Be it further enacted,* That after such levee or drainage district is so established by the County Court, and all damages paid or secured, if the County Court is of opinion that the report of the engineer already made is not sufficiently full or definite to enable the proper letting of contracts for the construction of the improvements, or, for other reasons, is not as full and definite as it should be, the court shall direct said engineer, or another appointed by the court for the purpose, to make a further and more complete survey and estimates of such district and cost of proposed improvements, and report to the court as to the same, giving all necessary and required information; how much of said improvement will be upon each tract of land, as nearly as practicable, giving definite estimates as to cost and character of work, and dividing the work into convenient sections for making contracts, etc., and giving such other particulars as the court may see fit to direct, and such report of such engineer shall be made and filed with the County Clerk without unreasonable delay; and if such engineer fails to act with reasonable promptness, the court may remove him and appoint another in his stead.

Commiss'nrs and Qualifications.

SEC. 11. *Be it further enacted,* That when the drainage or levee district, or other improvement herein provided for, shall have been located and established as provided for in this Act, the County Court shall appoint three Commissioners, one of whom shall be a competent civil engineer, and two of whom shall be freeholders of the county, not living within the levee or drainage district, and not interested therein, or in a like question, nor related to any party whose land is affected thereby; and they shall, as soon as practicable after their appointment, and after being duly sworn to perform their duty faithfully and impartially to the best of their ability, inspect and classify all the lands benefited by the location and construction of such drainage or levee district in a graduated scale of benefits, naming the tract or tracts of each owner and so classifying the same, each tract to be numbered according to the benefit received, as below provided, by the proposed improvement; and they shall make an equitable apportionment and assessment of the costs, expenses, cost of construction, fees and damages assessed for the construction of any such improvement, and make report in writing thereof to the County Court. In making said estimate and apportionment, the lands receiving the greatest benefit shall be marked on scale of one hundred, and those benefited in a less

Duties.

Apportionment of cost of construction.

Basis of assessment.

degree shall be marked with such percentage of one hundred as the benefit received bears in proportion thereto. This classification, when finally established, shall remain as a basis for all future assessments connected with the objects of said drainage or levee district, unless the County Court, for good cause, shall authorize a revision thereof. In making such classification, said Commissioners are authorized to divide the land of one owner lying in one body into more than one tract, and classify each subdivision thereof, if they are of opinion that portions of such entire tract will be more benefited than other portions, and especially when such entire tract is a large one, and that it will be more equitable and just to so classify it in subdivisions.

Notice of assessments.

In the report of such Commissioners they shall specify each tract of land by reasonable description and the ownership thereof as the same appears on the tax books of the county or as the same has been previously adjudged in the proceeding, and the court shall cause notice to be served upon each person whose name appears as the owner, and upon any person in actual occupancy of the land, which notice shall state the amount of special assessments apportioned to each owner on each tract or lot, the day set for hearing the same before the court, that all objections thereto must be made in writing and filed with the County Clerk on or before noon of the day set for hearing; and said notices shall be signed by the County Clerk and served at least five days before the time set for the hearing. If any such owner be a nonresident of the State, or his name or residence is unknown and can not be ascertained after diligent inquiry, then service of such notice upon the resident agent or attorney of such person shall be sufficient; if there be no such resident agent or attorney of such person, then the assessment may be made without notice, just as taxes are assessed without notice in such cases. When the day set for hearing has arrived, and the hearing is not continued by the court for good reason, as it may be, and when the hearing is had, the County Court shall proceed to hear and determine all objections made and filed to said report, and may increase, diminish, annul, or affirm the apportionment and assessments made in such report, or in any parts thereof, as may appear *to the court to* be just and equitable; but in no case shall it be competent to show that the lands assessed would not be benefited by the improvement; and when such hearing shall have been had, the County Court shall assess such apportionment so fixed by it upon the lands within such levee or drainage district. If the first assessment made by the court for the original cost of any improvement as provided in this Act is insufficient, the court may make an additional assessment in the same ratio as the first.

Additional assessment may be made.

New report may be ordered.

If for any reason the court annuls in toto, or sets aside such report of the Commissioners, it shall order them to make a new report, or shall remove them and appoint new Commissioners to act as in the first instance, if desired by the parties concerned.

Assessm'ts—how collected.

SEC. 12. *Be it further enacted,* That the assessments shall be levied upon the lands of the owners so benefited in the ratio aforesaid, and shall be collected in the same manner as taxes for county purposes, except as herein specially provided, and the funds so collected shall be kept as a separate fund, and shall be paid out only for purposes properly connected with such improvement, and on the order or warrant of the Judge or Chairman of the County Court.

Appeals.

SEC. 13. *Be it enacted,* That an appeal may be taken to the Circuit Court of the county from the order of the County Court fixing the assessment of benefits upon the lands in the same manner and time as herein provided for appeals from the assessment of damages, including the provisions as to consolidating cases, making transcript, etc., and certifying to the County Court the action and doings of the Circuit Court.

Counsel may be employed.

SEC. 14. *Be it further enacted,* That when any appeal is taken from any order of the County Court made in any proceedings before it under this Act, the County Court may employ counsel to represent the interests of the levee or drainage district affected by such appeal, on the trial thereof in the appellate courts, and the expenses of such counsel shall be paid out of the drainage fund of such district.

Drainage record.

SEC. 15. *Be it further enacted,* That in any county where a levee or drainage district is sought to be establish the County Court Clerk of such county shall provide a book to be known as the "Drainage Record," and to be paid for by the county, and said Clerk shall keep therein a full and complete record of all proceedings in each case arising under this Act, including all orders made by the County Court, and certified from the Circuit Court, and a copy of the original petition shall be enrolled in said Drainage Record, and all bonds required to be given.

Fees.

SEC. 16. *Be it further enacted,* That the fees of the County Clerk in proceedings under this Act shall be the same as for similar services now allowed by law, and in such case the County Court may allow said Clerk an additional sum for extra services, or services not covered by existing fee bills, or statutes, to be fixed by the court, and paid as other costs and expenses in the case or proceeding.

New apportionment made—when.

SEC. 17. *Be it further enacted,* That where any assessments made and levied under this Act can not for any reason be enforced, and part of the work has been done, the County Court shall proceed as to any or all lands benefited by said improvement in the same manner as if the appraisement and apportionment of benefits had never been made, in which event any payments already made shall be duly credited to those who have paid the same.

Directors—qualifications and terms.

SEC. 18. *Be it further enacted,* That after a drainage or levee district has been located and established as provided for by this Act, the County Court shall appoint two Directors of such district, said Directors to be owners of lands, or interested in lands, in such district, and at least one of those first appointed to be one of the petitioners for the establishment of said district, or his successor in estate or interest, said Directors to hold their offices for two years from the date of appointment, and these two thus appointed and their successors, together with the Judge or Chairman of the County Court, shall constitute the Directors, or Board of Directors, of such district, and as such Directors they shall have the general control and management of the business affairs of such district and supervision of the same, and be vested with power and authority to make contracts, as provided by this Act, for all improvement to be done in said district.

Board of Directors.

Vacancies and removals for *cause.*

If there should be a vacancy in the office of the Director appointed as aforesaid, because of death, resignation, or other reason, the County Court shall appoint another Director of like qualifications to fill such vacancy till the end of the two years' term, and for sufficient reason the County Court may remove a Director so apponited, but not till such Director has had at least five days' notice of the time of the hearing, and of the grounds on which he should be removed, as alleged, and he shall thus be entitled to be heard and to introduce proof upon the issue as to whether he should be so removed as a Director; and if, on the hearing, the decision of the County Court is that he be removed, he may appeal therefrom, on giving proper cost bond, to the Circuit Court of the county, where the matter shall be heard anew and such judgment given as that court deems just and proper. If a Director is removed, the County Court shall appoint another to serve the remainder of the two years' term, having like qualifications as to ownership of lands, etc., as herein provided.

Organization.

Bond of Treasurer.

At the end of each two years' term the office of the two appointed Directors shall be again filled by appointment by the County Court from among those owning or interested in lands in such district. The Judge or Chairman of the County Court shall be Chairman of said Board of Directors, and said Board shall elect one of the other Directors Secretary and Treasurer of the Board, and as such Treasurer he shall give bond in the sum of twenty-five thousand dollars to faithfully account for all money coming into his hands as such Treasurer, said bond to be approved by the County Court and payable to the county or State, for the use of such district, and shall be recorded in the Drainage Record.

Contracts may be made—when.

Notice for four weeks.

SEC. 19. *Be it further enacted,* That no contracts for improvements to be done in such drainage or levee district shall be made until after the Commissioners provided for by this Act have made their inspection, classification, and apportionment as directed in Section 11 hereof, nor until said question of classification and apportionment and assessment of benefits has been determined and settled by the court; but after the said Commissioners and the court have so acted then such contracts may be made by the Board of Directors of the district. Before entering into any contract for improvements, the Board of Directors of the improvement district shall cause notice to be given once a week for four consecutive weeks *in some* newspaper published in the county wherein such improvement is located, and such additional publication elsewhere as they may direct, of the time and place of letting the work of construction of said improvement, and in such notice they shall specify the approximate amount of work to be done in each section, and the time fixed for the commencement and completion thereof, and they shall award contract or contracts for each section of the work to the lowest responsible bidder or bidders therefor, or they may award the contract as a whole to the lowest responsible bidder, exercising their own discretion as to letting said work as a whole or in sections, and reserving the right to reject any and all bids, and re-advertise the letting of the work.

Deposits from bidder.

Each person bidding for such work shall deposit with the Treasurer of the Board of Directors in cash or certified check a sum equal to ten per centum of the amount of the bid, not in any event, however, to exceed ten thousand dollars, said deposit to be returned to him if his bid is not successful; and, if successful, to be retained as a guarantee only of his good faith in entering on said contract.

Bond of contractor.

The successful bidder shall be required to execute a bond, with sufficient sureties, payable to the county for the use and benefit of the drainage or levee district, in an amount equal to twenty-five per centum of the estimated cost of the work so let, or he may deposit such amount in cash with the Treasurer of the Board of Directors as security for the performance of his contract, and upon the execution of such bond or the making of such deposit, the deposit originally made with his bid shall be returned to him.

Engineer to be employed.

SEC. 20. *Be it enacted,* That the said Board of Directors shall employ a competent engineer to take charge and supervision of the construction of such improvement work, contracting with him for compensation for his services in such sum or at such rate as may be agreed upon, and to be paid as other expenses of such district. The Directors may remove such engineer and contract with another, if they see fit for any reason.

Removal for cause.

Monthly estimates of work done.

The engineer in charge of the construction shall furnish the contractor monthly estimates of the amount of work done on each section, and upon filing the same with the County *Court Clerk,* the Judge or Chairman of the County Court shall draw a warrant in favor of such contractor for eighty per centum of the value of the work done according to the estimate; and when said work is completed to the satisfaction of the Board of Directors and said engineer, and so certified by him and said Board, and such certificate is filed with the County Clerk, then the Judge or Chairman shall draw a warrant in favor of the contractor for the balance due. All such warrants shall be drawn upon the County Trustee or Treasurer as ordinary county warrants are drawn, but shall be payable only out of the fund provided for such drainage or levee district, and shall so state upon their face. The Board of Directors shall require such engineer to give bond in such sum as they may deem proper for the faithful performance of his duties, such bond to be payable to the county or State, for the use of such improvement district, and filed with the County Clerk and recorded in the Drainage Record.

Warrants—how paid.

SEC. 21. *Be it further enacted,* That whenever any railroad or public highway will be benficially affected by the construction of any improvement or improvements in such district established hereunder, it shall be the duty of the Commissioners appointed to classify and assess benefits to determine and return in their report the amount of the benefit to such railroad or highway, and notice shall be served as to such railroad upon its nearest station agent, as provided in case of an individual property owner; and as to such highway, notice shall be served upon the Judge or Chairman of the County Court, as in case of an individual property owner; and when such special assessments have been approved and fixed by the County Court, as hereinbefore provided, as to such railroad, it shall be a debt due personally from the railroad company, and, unless the same is paid by the railroad company as special assessment, it may be collected in the name of the county in any court having jurisdiction; and as to a highway, such assessment shall be paid by the county out of the general county fund or highway tax fund, such assessments to be paid into the fund of such drainage, levee, or improvement district.

Assessments against railroads.

How enforced.

SEC. 22. *Be it further enacted,* That whenever the making of such improvement across a public highway necessitates the building of a bridge over the same, the county shall

Bridges.

build and construct the same and pay all cost thereof out of the county bridge fund, if such fund be provided, and, if not, out of the general county fund.

Rights of land-owners assessed.

SEC. 23. *Be it further enacted,* That the owner of any land or lot that has been assessed for the payment of the cost of the location and construction of any ditch, drain, or water course, as hereinbefore provided, shall have the right to use the ditch, drain, or water course as an outlet for lateral drains from said land or lot.

Assessment—how collected.

SEC. 24. *Be it further enacted,* That the assessments as provided for by this Act shall be collected by the County Trustee, as county taxes are collected, except as herein provided, and the funds so collected shall be kept as a separate fund, and shall be paid out only for purposes properly connected with such improvement on the order or warrant of the County Judge or Chairman; but such assessments may be collected by bill filed in Chancery, as herein below provided, and no personal property of the owner of land so assessed shall be liable or distrained upon for such assessment, but the land so assessed only shall be liable for such assessment.

Character of work—how determined.

SEC. 25. *Be it further enacted,* That the improvement in the drainage districts herein provided for may consist solely, if so desired by those concerned, in the changing in whole or in part of the course or channel of a natural water course, or in straightening, as far as practicable, such water course, and cleaning out so much of its natural channel as it is desired to utilize; or the improvement in such drainage district may, in addition to the main ditch, or drain, or channel, include such other lateral and other ditches and levees as may be deemed proper or necessary.

Subdistricts may be established.

SEC. 26. *Be it further enacted,* That any person owning lands within any drainage district who desires to establish a subdistrict within the limits of the original district for the purpose of securing more complete drainage, may file his petition with the County Clerk, asking the County Court to establish such subdistrict, and describing the lands to be affected thereby so as to convey an intelligible description of such lands; and the bond and all other proceedings shall be the same as herein provided for the establishment, formation, and construtcion of original districts and improvements thereof, including the assessment of damages and assessment of benefits; and when established and constructed, it shall be and become a part of the drainage system of such drainage district, and be under the control and supervision of the Board of Directors of such drainage district; *provided, however,* such subdistrict shall only be established when conducive to the public health or welfare, or to the public benefit or utility; and *provided further,* that any special assessments made for the benefit of such subdistrict shall be secondary in lien and in right to the assessments for the benefit of the original district.

Drainage bonds may be issued.

SEC. 27. *Be it further enacted,* That if the County Court shall determine that the estimated cost of reclamation and improvement of such district of land or levee or drainage district is greater than should be levied in a single year upon the lands benefited, the court may fix the amount that shall be levied and collected each year, and may issue drainage bonds of the county, bearing not more than six per centum annual interest, said interest payable annually, and may devote such bonds at par, with accrued interest, to the payment of the expenses and work as it progresses, or may sell the same at not less than par with accrued interest, and devote the proceeds to such payment; and if, in the sale of said bonds, a premium is received, such premium shall be credited to the drainage fund; and should the cost of such work exceed the estimate, a new apportionment of the assessment may be made and levied and other bonds issued and sold in like manner; but in no case shall the bonds run longer than twenty years. Any property owner may pay the full amount of the benefit assessed against his property before such bonds are issued and receive a receipt in full therefor. Such payment shall be made to the County Trustee, and it shall be the duty of the County Clerk to certify to the Trustee the amount of any such assessment when requested to do so, and the Trustee shall enter the same upon the assessment lists in his hands in a separate place provided therefor, and shall furnish the County Clerk with duplicate receipts given for all assesments so paid in full, one of which the Clerk shall deliver to the Judge or Chairman of the County Court, and the Trustee shall also give a receipt to the property owner so paying in full.

Proceeds of issue.

New apportionm't and additional bonds may be issued.

Duties of Clerk and Trustee.

Terms of bonds.

The terms and times of payment of the bonds so issued shall be fixed by the Board of Directors of the improvement district, and such bonds shall be signed by the Judge or Chairman of the County Court and countersigned by the Clerk of the County Court, each of said officers signing his name officially, and shall be verified either by the county seal or seal of the County Court Clerk. Said bonds shall be issued for the benefit of the district numbered thereon, and each district shall be numbered by the County Court and recorded by the County Clerk in the Drainage Record, said record showing specifically the lands embraced in said district and upon which the assessment has not been previously paid in full.

How signed.

For what district issued.

How payable.

Each bond shall show expressly upon its face that it is to be paid only by assessments levied and collected on the lands within the district so designated and numbered, and for the benefit of which district such bond is issued; nor shall any assessment be levied or collected for the payment of said bond or bonds, or the interest thereon, on any property, real or personal, outside the district so numbered, designated, and benefited. Such bonds shall be in denominations of not less than fifty dollars; and when such district lies in more than one county, the County Court of each county shall so determine whether bonds shall be issued to meet the expenses, etc., of the improvement so far as the lands of the district lie in that county; and if so issued, the bonds shall be signed by the Judge or Chairman of the County Court of such county, and countersigned by the County Court Clerk, and verified by the county seal or seal of the County Clerk, and shall be payable only out of the assessments levied for such improvement on the lands in such county, as provided hereby when such district is wholly in one county.

Denominations.

Warrants may be issued—when.

SEC. 28. *Be it further enacted,* That if the Board of Directors of any improvement district provided for by this Act deems best instead of issuing bonds, they may direct that warrants shall be issued or drawn on such district, or on the County Trustee, by the Judge or Chairman of the County Court, to be paid out of the funds of such district only, and at such times as the assessments may be due, or as may be deemed best, the time of the maturity of assessments as fixed being considered, such warrants to be issued or drawn for all lawful demands on such district, and to bear interest at not more than six per centum per annum.

When district is in more than one county.

SEC. 29. *Be it further enacted,* That where a proposed or desired improvement will require a location in more than one county, applications by petition shall be made to the County Court of each of said counties, as provided by this Act, for applications where the improvement to be made lies wholly in one county, and signed by one or more persons owning lands lying in each county to be affected, or assessed for the proposed improvement; and when such petitions have been filed, the County Court of the county in which the larger or largest per centum of the lands to be affected by such improvement lies, shall appoint a competent engineer to make survey, etc., of such proposed improvement district in the same manner as when the proposed improvement lies wholly in one county, and such engineer shall proceed in the same manner as when the improvement lies wholly in one county, and said engineer shall make out duplicate reports of his survey and work and file one with each of the County Court Clerks in the counties where the petitions for such improvement is filed; and after such reports of the engineer are so filed, the County Court of each of said counties shall proceed as herein provided for improvement districts located wholly in one county till the point in the proceeding is reached when viewers are to be appointed to assess damages, as provided by this Act; and as to such viewers, the County Court of the county in which the larger or largest per centum of the lands to be affected or assessed on account of such improvement is located, or lies, shall appoint two viewers, and one of such viewers shall be appointed by the County Court of each of the other counties concerned, if more than one other county; and if only one other, by the County Court of such county, said viewers to have the same qualifications, etc., as hereinbefore provided for viewers. When so appointed, the viewers shall meet as soon as practicable at some convenient point to be designated by the Clerk of the County Court of the county, the court of which appoints two of the viewers, and shall then proceed to assess damages, etc., as hereinbefore provided for dis-

Duplicate reports of engineer.

Proceedings.

Viewers.

tricts lying in one county only, said engineer rendering them like assistance, as hereinbefore provided; and when their work is completed, the viewers shall make out one copy of their report for each of said counties, signing same, and shall file a copy of such report with each of the County Court Clerks of the counties where such petitions have been filed for the establishment of such improvement or district.

Commissioners.

SEC. 30. *Be it further enacted,*. That when the viewers have so reported, each of said County Courts shall proceed as herein provided in other cases till the point is reached to appoint Commissioners to make assessments and apportion the same as to the lands affected, when the County Court of the county in which the larger or largest per centum of the land lies to be assessed or affected, shall appoint two of said Commissioners, one of these appointees to be a competent engineer, and the other County Court, or Courts, shall appoint one of said Commissioners each, the Commissioners so appointed to have the same qualifications as hereinbefore provided; and when so appointed, they shall, as soon as practicable, meet at some convenient place to be desgnated by the County Court Clerk of the county, the court of which has appointed two of the Commissioners, one being an engineer, and shall then proceed to assess the lands in such district, and apportion the assessments in the same manner as herein provided where such district lies wholly in one county, and shall report in like manner, and shall file a copy of their report with the Clerks of the County Courts in each county having lands within such improvement district; and when such Commissioners have so reported, each of said County Courts shall proceed as to said reports, and in levying assessments, etc., as provided by this Act, in cases of districts lying in one county only.

Board of Directors.

SEC. 31. *Be it further enacted,* That in cases of levee or drainage districts so lying in more than one county, the Board of Directors of such districts shall consist of one member from each county, to be appointed by the County Court of such county, and the Judge or Chairman of the County Courts of each of said counties shall be members of such Board of Directors, and the qualifications, powers, and duties of such Board of Directors shall be the same as provided by this Act for Boards of Directors and members thereof in improvement districts lying entirely in one county. The County Courts of the respective counties shall have the same right to remove the viewers, Commissioners, and Directors appointed by such court, and to appoint others in their stead, and to fill vacancies that the County Courts have, as provided by this Act, where such improvement district lies wholly in one county. The Judge or Chairman of the County Court of the county in which the larger or largest per centum of the lands of such improvement district lies shall be Chairman of such Board of Directors, with authority to call meetings of the Board; and said Board shall elect one of the appointed Directors Secretary and Treasurer of the Board of Directors, and such Treasurer shall give bond, etc., as provided by this Act, such bond or a duplicate of same to be filed with the County Clerk in each of the counties and recorded in the Drainage Record, said bond to be taken before and approved by the County Court of the county in which the larger or largest per centum of the lands of the district lies.

Organization.

Bond of Treasurer

SEC. 32. *Be it further enacted,* That the assessments provided for by this Act, and to be collected for the purposes herein provided, shall be entered upon a book to be provided by the County Court Clerk, at the expense of the county, for this purpose, in a similar manner to that in which taxes are entered upon the tax books, such books showing the tracts of lands, amounts of assessments, etc., and such book, when so made out, shall be furnished to the County Trustee for collection of assessments so levied. Said book shall be called "Drainage Assessment Book," and shall be made out by the County Court Clerk of the county in which the particular assessment is levied, and said book may be made out but once, if practicable, for the entire assessment for the particular improvement project; but if not practicable, then a new drainage assessment book may be made out for a shorter period, or for each year, and furnished the County Trustee; and the assessments levied under the provisions of this Act shall become due and payable and delinquent at the same time State and county taxes become due and delinquent, and such assessments shall bear interest at the legal rate after they become delinquent.

Drainage assessment book.

Assessments become liens upon lands.

SEC. 33. *Be it further enacted,* That the assessments provided for by this Act, when made and levied, shall be and become valid liens upon such lands so assessed just as State and county taxes are liens upon lands; and when such assessments have been due and delinquent for sixty days, bills may be filed in the Chancery Court of the county, or Chancery District, in which the lands lie, upon which such assessments are due and delinquent, for the collection thereof out of such lands by a sale thereof in all cases, except in cases where the assessment is made against a railroad company or a public highway, as herein provided for. Such bills in Chancery shall be filed in the name of the county in which the lands are situated for the use of the improvement district for the benefit of which the assessments were made, and against the owners, if known, and, if unknown, against them as such; and the owners of all lands upon which such assessments are delinquent may be made defendants to the same bill as parties thereto. When it is desired by the Board of Directors, or other interested party entitled to sue, to file such bill, the County Trustee, upon request shall make out a statement or list, showing all the lands upon which such assessments are so delinquent, and the names of the owners thereof, as appears upon the Drainage Assessment Book, or showing any tract or tracts assessed to unknown owners, if such be the case, and certify as Trustee to the correctness of such statement or list as the same appears upon said book, and in such Chancery suit such certified statement or list shall be prima facie proof of the facts so certified to, and that such assessments are delinquent, and sufficient proof to authorize a decree of sale in the absence of rebutting proof of the facts shown by such certified statement. Such suits in Chancery shall be proceeded with as other suits are in said court, except that the court may hear the case as to any one or more of the defendants, whether ready to be heard as to other defendants or not, and so proceed to sale and final decree as to any one or more of the defendants, though the case be not disposed of, as to other defendants. When a sale is ordered in such suits, and is made and reported, the Clerk and Master of such court so making the sale shall report what public taxes are a lien upon any tract so sold in favor of the State, county, or any municipality, and the

Delinquent lists.

Prima facie evidence.

Assessment liens—how enforced.

Sale of lands may be ordered.

court shall see that this is done, and any such taxes, if the sale be confirmed, shall be first paid out of the proceeds of such sale before such delinquent assessments are paid. Upon confirmation of such sale by the Chancery Court, it shall divest title out of the owner and vest it in the purchaser, and award a writ of possession if asked for; but where title is so vested in a purchaser the land so purchased shall still be subject, in the hands of the purchaser, his heirs, or assigns, to any other assessments not yet due, or unpaid, that may have been made and fixed or levied upon it at the time of such confirmation of sale, for the benefit of the improvement district on account of which sale has been made. When any such sale is made by decree of the Chancery Court, it shall be made for cash, and the owners of lands so sold shall have two years from the date of the confirmation of such sale in which to redeem the same by paying to the Clerk and Master of such court making the sale the amount paid by the purchaser for said lands, with legal interest thereon, to the date of redemption, and also a further sum equal to ten per centum of the amount so paid by the purchaser for said land. In such proceedings in Chancery Court, the court shall enter a decree in the cause, tending to the suit shall be allowed as a fee ten per centum of the amount found due as an assessment or assessments on each tract of land decreed sold, the same to be charged up in the decree as part of the judgment for which the land is to be sold; and when such lands are redeemed, as herein provided, and this fact is made satisfactorily to appear to the Chancery Court, the court shall enter a decree in the cause, adjudging the land so redeemed and declaring it to be the property of the owner so redeeming, or his heirs or assigns, if redeemed by his heirs or assigns; and if necessary may award a writ of possession to put the person so redeeming in possession of the land.

Writ of possesion may be given purchaser.

Time and terms of redemption.

Attorney's fees.

Decree of redemption may be had.

Provided, however, that infants, and persons who are lunatics or of unsound mind, shall have the further period of one year after the removal of such disability in which to redeem their lands sold under the provisions of this section and this Act, under like terms as to amounts to be paid, in redemption, as above provided.

Exceptions.

SEC. 34. *Be it further enacted,* That the assessments

Distress warrants may be issued.

provided for by this Act shall, if not paid by the owners of the land assessed, be collected only out of the land so assessed for improvement purposes, and shall not be collected, by distress warrant or otherwise, out of any other property, real or personal, of the owners of the land so assessed under the provisions of this Act.

Petitions may be signed by attorney or agent of petitioner.

SEC. 35. *Be it further enacted,* That it shall be a sufficient signing, in the sense of this Act, of the names of petitioners to the petitions herein provided for, if their names are signed by their attorney at law or by an agent authorized so to do.

Salaries and expenses.

SEC. 36. *Be it further enacted,* That engineers employed by Boards of Directors of improvement districts to supervise the work, etc., shall be paid for their services such salary or sums as may be agreed upon between them and such Board of Directors; that engineers appointed hereunder by the County Courts shall be paid for their services at such rates as the courts appointing them may fix, and, if not so fixed, at the rate of five dollars per day while engaged in the work, and, in addition, all actual traveling expenses, an itemized account of such expenses to be kept by them and reported and sworn to; that the viewers and Commissioners provided for by this Act shall be paid at the rate of three dollars per day while engaged in the work, and, in addition, all actual expenses, including board paid for, itemized accounts for the same being reported and sworn to; and that other necessary help aiding the engineers, viewers, or Commissioners—such as chain carriers, axmen, etc.—shall be paid not more than two dollars per day.

Compensation of Trustee and Clerks.

For collecting and paying out assessments under this Act, the County Trustee shall receive the same compensation he receives for collecting public taxes; and for any certified statements furnished by him, the same fees per one hundred words as are allowed Clerks of courts for certified copies of records; and if there be any services required of any person under the provisions of this Act, and the rate of pay therefor is not provided for hereby, then the County Courts shall fix the amount, or rate, of pay in such cases; *provided, however,* that the members of the Boards of Directors shall not be entitled to receive any pay for their services, but only be reimbursed or paid their actual expenses incurred on ac-

Expenses of Directors.

count of attending to their duties as Directors, an account of the same to be kept, made out, and sworn to by each.

Contractors to forfeit deposits—when.

SEC. 37. *Be it further enacted,* That if any person to whom the work, or any portion of the work, in such improvement district has been let shall fail to perform the same according to the terms specified in his contract, then the cash deposited by him shall be forfeited for the benefit of such district and be paid into its fund; or if bond has been given by such contracting party so failing, then recovery of the damages sustained may be had by suit in the name of the payee in such bond for the use of such district, and such damage on judgment therefor collected and paid into the fund of such district.

Mutual agreement dist'cts may be established.

SEC. 38. *Be it further enacted,* That the owners of land which require combined drainage may provide for the establishment of a drainage district, or location and construction of drains, ditches, and water courses upon their own lands by mutual agreement in writing, duly signed, acknowledged, and filed with the County Clerk. Such agreement may include the location, the character of work to be done, the adjustment of the damages, the classification of the lands to be benefited thereby, the amount of special assessments to be levied, when the same shall be levied, or so many of these or other provisions as may be agreed upon, and to such extent shall be as valid and binding as though performed in the mode and manner provided for in this Act. Upon the filing of the agreement with the County Court Clerk, the County Court shall establish such drainage district and locate the ditch, drain, or water course provided for in said mutual agreement according to the terms thereof and shall thereafter have full and complete jurisdiction of the parties and subject-matter, and order such procedure under the provisions of this Act as may be required or necessary to carry out the object, purpose, and intent of such agreement, and to complete and construct the desired improvement, and shall retain jurisdiction of the same as fully as in other cases made and provided for in this Act.

Preliminary expenses—how paid.

SEC. 39. *Be it further enacted,* That the preliminary expenses of such levee or drainage district, ditch, drain, or water-course improvement provided for by this Act (not including contracts for construction) may be paid by order of the Quarterly County Court of the county in which the lands lie of such improvement district out of the general county fund, the same, if so paid, to be refunded to the county out of assessments collected from the lands of such improvement district when so collected; and if not so repaid, for any reason, then to be adjudged against and collected out of the bond of the petitioners required by this Act, and thus repaid to the county. If the Quarterly County Court should not see fit to order such preliminary expenses so paid, and the parties to whom such expenses may be owing are not willing to agree to wait till a fund for their payment can be provided by special assessments upon such district, then the County Court by proper order shall require the petitioner or petitioners to pay to the County Court Clerk a fund sufficient to pay such preliminary expenses, and the bond required of petitioners by this Act shall be liable for such preliminary expenses, and judgment thereon may be rendered at any time by the County Court to the end that such fund for expenses be provided, just as courts render judgments on cost bonds, and one such judgment shall not prevent other judgments on the same bond, so the sum of the judgments does not exceed the penalty of the bond; *provided, however,* such fund for expenses may be paid in from time to time, under the orders of the court, as the same may be needed; and *provided further,* that all sums so paid by the petitioners or their sureties on their bonds shall be refunded and repaid to the person or persons so paying the same out of the funds of such improvement district when such funds have been realized under the provisions of this Act.

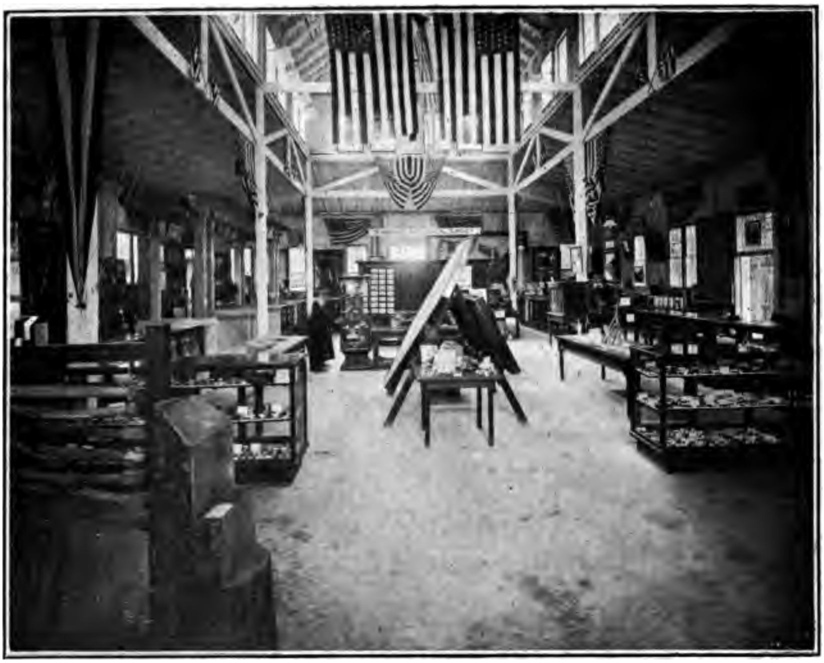
This act not to apply to Reelfoot Lake.

SEC. 40. *Be it further enacted,* That this Act is not intended to apply to Reelfoot Lake and the waters thereof, or to authorize the draining of same, and this Act shall not be construed to in any way authorize the drainage of said lake.

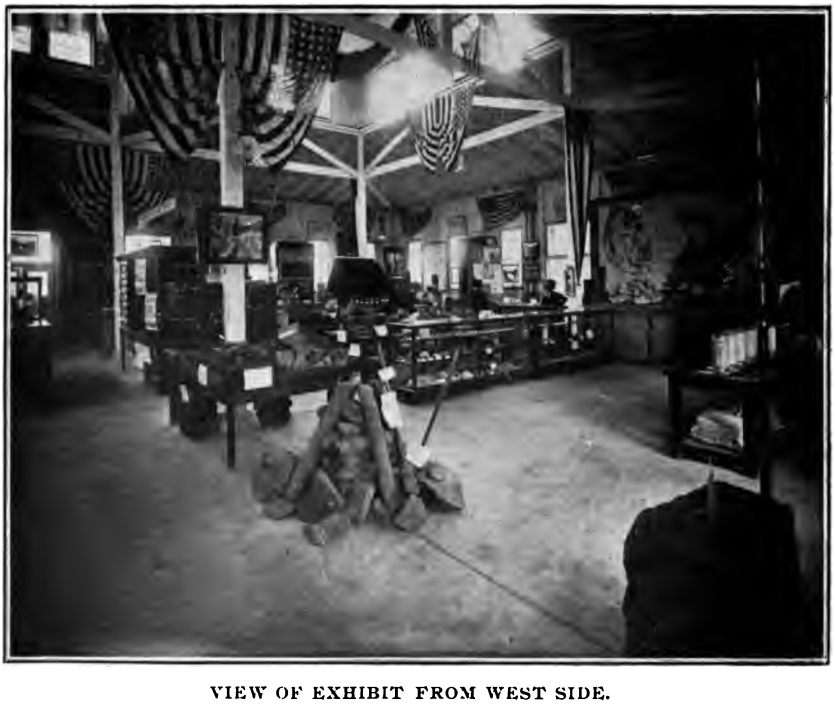
SEC. 41. *Be it further enacted,* That this Act take effect from and after its passage, the public welfare requiring it.

Passed February 25, 1909. WILLIAM KINNEY,
Speaker of the Senate.
M. HILLSMAN TAYLOR,
Speaker of the House of Representatives.

Approved April 20, 1909.
MALCOLM R. PATTTERSON,
Governor.



VIEW OF EXHIBIT FROM NORTH END.



VIEW OF EXHIBIT FROM WEST SIDE.

Views of the Mines and Minerals Exhibit at the Appalachian Ex*position, Knoxville,* Tenn., made by the Tennessee Geological Survey.

STATE OF TENNESSEE
STATE GEOLOGICAL SURVEY
GEO. H. ASHLEY, STATE GEOLOGIST

BULLETIN 4

ADMINISTRATIVE REPORT
OF
STATE GEOLOGICAL SURVEY

1910

BY GEO. H. ASHLEY,
State Geologist

NASHVILLE
FOSTER & PARKES COMPANY
1911

CONTENTS

PAGE

Letter of Transmittal 4
Introduction 5
  Establishment 5
  Organization 5
  Equipment 8
  Purpose 8
  Scope of work 9
  Cooperation with federal bureaus 9
Work of the Survey 10
  Office work 10
    Administrative work 10
    Bureau of information 10
    Preparation of reports 11
    Maps and illustrations 12
    Preparation of exhibits 12
    Publications of the Survey 12
  Field work 14
    How conducted 14
    Cooperative field work and study 15
    Field work in 1910. By State Geologist 15
    Stratigraphic and structural geology 16
    Coal 16
    Iron 17
    Marble 17
    Oil and gas 18
    Phosphate 18
    Zinc 18
    Clays 18
    Copper 18
    Drainage reclamation 19
    Water resources 19
    Road building 20
    Forestry 20
Financial Statement 21
Program and Recommendations for 1911 22
Appendices 32
Appendix "A"—Statement concerning forest conditions in Tennessee by U. S. Forest Service 33
Appendix "B"—Press bulletins giving synopsis of reports published 37
Appendix "C"—Types of miscellaneous bulletins, special papers and addresses 41
  (a) The Geological Survey and the Coal Men ....
  (b) State Geological Survey and the Farming Interests ....
Appendix "D"—Exhibits 55
  Exhibit at Appalachian Exposition, Knoxville, September 12 to October 12, 1910 55
  State Geological Exhibit at Nashville 57

MARCH 20, 1911.

To the Members of the Fifty-seventh General Assembly, of Tennessee:

In accordance with the Act creating the State Geological Survey there is submitted for your investigation the report of the State Geologist, covering a period from May 1, 1910, when he took charge of his office, to December 19, 1910. We bespeak your careful consideration of the report, showing the extensive field already occupied by the Survey and the work done by it during the few months of its existence.

Respectfully submitted,

BROWN AYRES,
Secretary of the Commission.

BEN W. HOOPER, Governor,
Chairman of the Commission.

LETTER OF TRANSMITTAL.

NASHVILLE, TENN., December 15, 1910.

To His Excellency, the Governor, and Members of the Geological Commission:

GENTLEMEN—I have the honor to transmit herewith my report as State Geologist, as the law requires, for the term ending December 19, 1910. The report recounts the establishment of the Survey, its organization May 1, 1910, reviews the work accomplished during the seven and one-half months of its existence and the present condition of the Survey, and makes certain recommendations looking toward the future work of the Survey.

Very respectfully,

GEO. H. ASHLEY,
State Geologist.

INTRODUCTION.*

Establishment.—The State Geological Survey of Tennessee was created by an Act passed April 30, 1909. The Act creating the Survey designated an *ex-officio* commission to have charge of the work and specified their duties; it provided for the appointment of a State Geologist, and specified his duties; it described the object and conduct of the Survey, and allotted $15,000 a year for its carrying on. The Act specified that the funds should not be available until May 1, 1910.

Organization.—On March 16, Mr. Geo. H. Ashley, then of the U. S. Geological Survey, was appointed State Geologist, and Prof. L. C. Glenn, of Vanderbilt University, and Prof. C. H. Gordon, of the University of Tennessee, associate geologists, the same to take effect May 1, 1910.

As at present organized, the Geological Survey's force consists of the State Geologist, two associate geologists on per diem, and one clerk or stenographer. Three temporary field assistants are or have been employed and three temporary draftsmen. One unskilled assistant cares for the State geological exhibit, runs the mimeograph, etc. In addition, three experts in the State have cooperated in the preparation of special reports; two members of the Geologic Branch of the U. S. Geological Survey, three members of the Topographic Branch of that Survey, two members of the Drainage Investigations Division of the U. S. Department of Agriculture, and two members of the U. S. Forest Service have cooperated in areal and special work in Tennessee. In addition six topographic assistants, obtained locally, have been on the Survey's pay roll in connection with the topographic work in West Tennessee.

The following list contains the names of the Geological Commission and all of those engaged in the work, either directly for the Survey or in cooperation with it:

---

*The establishment, organization, purpose, scope and work of the Survey have been quite fully explained in Bulletin 1-A, published soon after the establishment of the Survey. Copies of this bulletin can be obtained on request.

COMMISSIONERS.

Gov. Ben W. Hooper, Chairman.
Col. John Thompson (State Commissioner of Agriculture).
R. A. Shiflett (State Mine Inspector).
President Brown Ayres (University of Tennessee), Secretary.
Chancellor J. H. Kirkland (Vanderbilt University).
Vice Chancellor William B. Hall (University of the South).

ADMINISTRATIVE AND OFFICE WORK.

Geo. H. Ashley, State Geologist.
Elizabeth Cockrill, Clerk.
B L. DePierri, Draftsman.

GEOLOGICAL SECTION.

Prof. L. C. Glenn (Vanderbilt), Associate Geologist. Coal, water resources.
Prof. C. H. Gordon (University of Tennessee), Associate Geologist. Appalachian Expositon.
Mr. Wilbur A. Nelson (Nashville), Assistant Geologist. Clays.
Prof. R. P. Jarvis (University of Tennessee), Cooperating Geologist. Iron.
Dr. W. C. Phalen (U. S. Geological Survey), Cooperating Geologist. Areal survey, coal.
Mr. M. J. Munn (U. S. Geological Survey), Cooperating Geologist. Oil and gas.
Mr. Lucius P. Brown (State Chemist), Cooperating Geologist. Phosphate.
Mr. S. W. Osgood (Knoxville, Tenn.), Cooperating Engineer. Zinc.
Prof. J. A. Switzer (University of Tennessee), Cooperating Engineer. Water powers.
Mr. Henry H. Hart (Chattanooga), Field Assistant. Areal surveys.
Mr. John H. Agee (LaFollette), Field Assistant. Phosphate, soil surveys.

FORESTRY SECTION.

Mr. R. Clifford Hall (U. S. Forest Service), Cooperating Forester.
Mr. W. W. Ashe (U. S. Forest Service), Cooperating Forester.
Mr. Ernest D. Clark (U. S. Forest Service), Cooperating Forester.

TOPOGRAPHICAL SECTION.

Mr. E. L. McNair (U. S. Geological Survey), Topographer.
Mr. A. F. McNair (U. S. Geological Survey), Junior Topographer.
Mr. J. M. Rawls (U. S. Geological Survey), Topographic Aid.
Mr. M. W. Gray, Recorder.
Mr. Robt. L. Taylor, Jr., Chainman.
Mr. Edmond C. Kain, Chainman.
Mr. L. E. Peck, Rodman.
Mr. H. H. Dick, Rodman.
Mr. Bruce Reed, Rodman.

DRAINAGE SECTION.

Mr. Arthur E. Morgan (U. S. Department of Agriculture), Drainage Engineer.
Mr. S. H. McCrory (U. S. Department of Agriculture), Drainage Engineer.
Mr. J. V. Phillips (U. S. Department of Agriculture), Drainage Engineer.

Geological work in cooperation with the U. S. Geological Survey has been under the personal supervision of Mr. David White, who gave the greater part of a month to the supervision in the field of the cooperative work being done in this State. The topographic work done under cooperation has been under the supervision of Mr. Frank Sutton; the drainage investigations under Mr. C. G. Elliott, and the forestry work under Mr. J. G. Peters, all of whom have visited the State during the progress of the work. The large topographic parties engaged in the survey of the stream bottoms of West Tennessee, that do not appear on the pay roll of this Survey, are not included in the preceding list. The topographers in charge of this work have been Messrs. C. Hartmann, Jr., S. P. Floore, J. DePuy, W. H. Griffin and J. M. Rawls. Nor do the names appear of several who were employed for short periods for stenographic, drafting and other work The preceding list also does not include the names of members of the U. S. Geological Survey and others engaged in geologic, topographic or other scientific work in the State to which the State Survey did not contribute.

The work of the Survey has been divided into three parts, or as they may be termed bureaus: (*a*) bureau of administration; (*b*) bureau of survey; (*c*) bureau of information and publication.

The bureau of administration work involves: (*a*) plans and estimates; (*b*) bids, purchases, contracts; (*c*) property and equipment; (*d*) correspondence; (*e*) records; (*f*) accounts; (*g*) supervision. This includes the internal machinery of the Survey.

The bureau of survey covers the obtaining of data whether in the field, the laboratory or the library. This covers the bulk of the work and expense of the Survey to date.

The bureau of information covers the giving of information, informally or formally. It includes: (*a*) informal communications and correspondence; (*b*) newspaper items and press bulletins; (*c*) special articles and addresses; (*d*) bulletins (the regular publications of the

Survey); (*e*) maps and illustrations; (*f*) exhibits; (*g*) educational work.

Equipment.—The Survey office is at present on the second floor of the Capitol Annex. The State Geological exhibit occupies the whole of the east side of that building on the third floor, and the other rooms on the third floor are used in connection with the preparation of that exhibit. The office has been equipped with the usual office furniture, and in addition to the usual files, are map cases, specimen cases, index cases, well record cases, drawing tables, etc., with their equipment of index cards and maps, record cards for filing information, files for manuscripts, note books, etc. The best business methods of recording, filing and cross referencing correspondence has been followed. The mimeograph has been used in preparing press bulletins, circulars, etc. The office also contains the Survey library, which has been started, and the geological library of the State Geologist of several thousand volumes and pamphlets upon which dependence will be placed until the Survey library has been built up.

The exhibit at Nashville occupies twelve glass floor cases, four table wall cases, five drawer cases, over one hundred feet of step shelving and six ten-leaf hanging wall cases for maps and photographs.

Purpose.—*The purpose of the Survey may be briefly stated: The Geological Survey of Tennessee exists to obtain and publish accurate, definite and unbiased information on the State's natural resources for the purpose of increasing the wealth and well-being of the State and its citizens through a larger and better use of those resources.

---

*The following statement from Bulletin 1-A, page 10, explains the purpose and value of the Survey more fully:

"The Survey will be of direct value to the State in several ways: (1) by serving as the State's expert in determining the value, etc., of the State's present large holdings of mineral lands, or of any proposed additional purchases or sales; (2) by supplying the facts and information necessary to intelligent legislation concerning the State's resources; (3) by conserving the State's resources through leading to better methods of obtaining and using them; (4) by helping to bring into the State new capital for investment and the immigration of new citizens; (5) by keeping money in the State through aiding in the establishment of local industries to supply local needs, and by bringing additional money in by enlarging the output of farms, mines, and factories; (6) by leading to added sources of income for the State.

"The Survey will be of indirect value to the State through its value to the individual citizens for whose welfare the State exists.

"It is of value to the landowner by showing what ores, minerals, rocks, or other resources underlie his land; their depth, volume, character, and value, and to that extent it affects the possible sale value of his land; and, second, by suggesting such use of his land as will make it yield the largest possible return. It is of value to those having capital to invest by supplying unbiased information upon which investments may be made or industries established. It is of value to transportation interests by increasing the volume of both crude and manufactured materials to be moved, through an increased production and an increased demand. It is of value to the purchasing public, which includes most of us, by reducing costs through the production in the State of things that must otherwise be obtained from without, and through increasing the supply of those things. It is of value to the man without work by increasing the demand for labor through the starting of new or enlarging of old industries.

"In so far as the Survey may aid in the abating of the smoke nuisance in the cities, in obtaining cheaper light and power through a larger use of our water powers, in aiding and making effective plans for the drainage of bottom lands, in converting poor farm lands into good farm lands, and in a thousand other ways, it may make it possible for all citizens to have more of the comforts and luxuries of life."

Scope of Work.—*The Survey is primarily a bureau of information on certain subjects. This implies, first, the collecting of the information; second, the study, systematizing, filing, or preparation of that information; and, third, the supplying of that information.

The subjects on which the Survey is to serve as a bureau of information have already been outlined in Section 5 of the Act under which the Survey is established. They may be grouped as follows:

1. General Geology, mineralogy, physics, and chemistry, so far as they relate to the natural resources of this State.
2. Geography of the State.
3. Metals and their ores.
4. Fuels and fertilizers.
5. Structural materials and materials used in the arts.
6. Water and water power.
7. Soils.
8. Reclamation of land.
9. Forests, roads, etc.
10. Miscellaneous materials and products.

Cooperation with Federal Bureaus.—To secure the largest returns for the money available, cooperation has been carried on with a number of bureaus and departments of the United States Government, as well as with other departments of the State Government. In these cooperative agreements, as a rule, experts of the Federal Government have done the work, and the State Survey has borne half of the expenses and published the reports. In some cases the State Survey furnished assistants, paying their salary and field expenses. In this way the State has had the benefit of work by men of large experience, such as it could hardly afford to employ for the short time they are needed with the funds at its command. Again, in many cases, these men bring to the work in Tennessee a wide acquaintance with the conditions in adjoining States, and not infrequently they have already had a greater or less experience in this State in the line of the particular subject involved.

---

*This subject is more fully explained in Bulletin 1-A, pages 12-21.

WORK OF THE SURVEY.

OFFICE WORK.

Administrative Work.—The administrative work has consisted of making plans for the work, correspondence and conference relating to their carrying out, the obtaining of bids for the purchase of equipment and supplies, the making of contracts, especially of cooperative agreements, the care of the Survey equipment and property, the conduct or supervision of work while in progress, and of the reports when the work is completed, and the distribution of the reports, the administration of the finances of the Survey, the classification and filing of information needed for reference or for reports in progress or contemplated.

In the preparation and obtaining of this information, it has been found necessary to prepare a rather complete card index to all of the publications and also by the usual means followed in business houses to get the data available in such shape that it can be readily referred to. Among other things this has involved the preparation of maps of the State, on which can be shown by different colored tacks the location of deposits of various kinds, the mines, quarries and plants where these resources are being obtained and worked up.

Bureau of Information.—A large share of the time of the State Geologist has gone into the work of answering personal and written inquiries of all kinds regarding the mineral resources of the State. These come from landowners, investors, railways, cities, towns, commercial associations, teachers and pupils, and, in fact, from all classes of people, both within and without the State. The aggregate number is very large, and the number of inquiries per day is constantly increasing. This work is believed to be an important function of the Survey, though it necessarily hampers the larger and systematic study of the

State's resources. At present it is often necessary to write long replies describing the occurrence and character of resources about which inquiries are made. It is hoped that with the publication of the preliminary bulletins, many of the inquiries can better be answered by sending such bulletins. In addition, the Survey has been ever mindful of opportunities to advertise the State's resources and many letters have been sent out to those who might be interested in examining further into the opportunities this State offers for investment and the building up of new enterprises.

In order to give the results of the Survey's work the widest publicity, the distribution of each bulletin has been accompanied with a press bulletin, giving the principal facts contained in the bulletin. These have been sent to all of the newspapers in the State, and to all of the technical journals in the country, in the lines involved. As a matter of fact these press bulletins have been very liberally used by such outside journals, possibly more so than by the smaller local newspapers in the State. In some cases the technical journals have used considerable extracts from the bulletins themselves, and in one or two cases have requested the use of plates used in the bulletins to accompany their extracts. A large part of the outside inquiries may be traced directly to these notices. In addition to the press notices accompanying the bulletins issued, others have been issued from time to time, explaining the work or calling attention to economic conditions found in the progress of the work.

Besides the general articles referred to, a number of articles have been specially written for the technical journals both inside and outside of the State, and a number of addresses have been prepared on various subjects and given in various parts of the State.

Preparation of Reports.—After the completion of any given piece of field work, a large amount of office work is necessary, digesting, systematizing and boiling down the information gathered, the study and analysis of specimens collected, the preparing of maps, cross sections and other drawings, the writing of the report, the critical review of the manuscript by other members of the Survey or others, the proof reading of the report in press, and later its distribution. During this first year many of the publications prepared have involved a very full review of all papers and reports previously published on that subject, many of which are now out of print or rare. During the year Bulletins 1-A, 2-A, 3-A and 4 were prepared in the Nashville office printed and distributed. Bulletin 1-B has been prepared and is in press Bulletins 5, 6, 7 and 2-B are in preparation.

Maps and Illustrations.—Considerable time has been given in the office to preparing a new geological map of the State, using all of the information available. There has been no large scale map of the State published in many years, and the work has developed many problems, some of which will have to be worked out in the field.

In the field many photographs have been taken, part of which will be used in the reports, part in cases in the exhibits and a part for lantern slides to use later in talks on the resources of the State. As most of the bulletins are accompanied by especially prepared maps, the preparation of these has formed no small part of the office work.

Preparation of Exhibits.—This work includes the care of specimens received from the field, or as donations, the planning of suitable rooms, cases and mountings, the arranging of exhibits, their labeling, their exhibition or explanation to teachers and others. Two such exhibits have been prepared this year, one at Knoxville in connection with the Appalachian Exposition, the second the beginning of a permanent exhibit at Nashville. These exhibits are described more in detail in Appendix E.

Publications of the Survey.—The formal publications of the Survey are issued in the form of bulletins. This Survey has departed, to some extent, from the method adopted by many of the State surveys of issuing an annual report. On the contrary, as soon as any paper or report, complete in itself, has been ready, it has been printed and issued. In some cases where these papers are very short and two or more are under preparation or in anticipation along closely related lines, they are gathered into one bulletin, and the separate papers are designated by the letters, A, B, C, etc. Each paper, however, is printed as soon as ready, without reference to the others which may later be combined with it, to form that bulletin. These bulletins have been distributed over the State to all those known to be professionally interested in the subject with which they deal, or who have requested information on that subject, to all boards of trade or corresponding bodies in the State, and the principal bodies of that nature in adjoining States as far north as New York and west as far as North Dakota, to the libraries of the State, including the school libraries of secondary or grammar grades, to State, city and scientific libraries outside of the State, to members of the State Legislature and other State and county officials. With the exception of five hundred copies of each edition, the bulletins are sent free upon request accompanied by postage. Five hundred copies of each edition are held to be sold at the cost *of printing in* order that late comers, and especially those who may have a financial interest in the subject involved, may have an opportunity of getting such reports. The following list shows the bulletins already issued or in preparation:

Bulletins Nos. 1-A, 2-A, 2-E, 2-G and 3, issued.

Bulletin No. 1. Geological Work in Tennessee (Part A issued).
  A. The establishment, purpose, object and methods of the State Geological Survey; by Geo. H. Ashley; 33 pages, issued July, 1910; postage 2 cents.
  B. Bibliography of Tennessee Geology and related subjects; by Elizabeth Cockrill (in press).
  C. History of Geological Work in Tennessee; by L. C. Glenn (in preparation).

Bulletin No. 2. Preliminary Papers on the Mineral Resources of Tennessee, by Geo. H. Ashley and others. (Parts A., E. and G. issued.)
  A. Outline Introduction to the Mineral Resources of Tennessee, by Geo. H. Ashley, issued September 10, 1910; postage 2 cents.
  B. The coal fields of Tennessee, by Geo. H. Ashley (in preparation).
  C. The Iron Ores of Tennessee, by R. P. Jarvis (in preparation).
  D. The marble of East Tennessee, by C. H. Gordon (in press).
  E. Oil Development in Tennessee, by M. J. Munn (issued); postage 2 cents.
  F. The Phosphate Deposits of Tennessee, by Lucius P. Brown (in preparation).
  G. The Zinc Deposits of Tennessee, by S. W. Osgood (issued); postage 1 cent.
  H. Preliminary Geological Map of Tennessee (in preparation).

Bulletin No. 3. Drainage Reclamation in Tennessee; 74 pages, issued July, 1910; postage 3 cents.
  A. Drainage Problems in Tennessee, by Geo. H. Ashley; pp. 1-15; postage 1 cent.
  B. Drainage of Rivers in Gibson County, Tennessee, by A. E. Morgan and S. H. McCrory; pp. 17-43; postage 1 cent.
  C. The Drainage Law of Tennessee; pp. 45-74; postage 1 cent.

Bulletin No. 4. Administrative Report of the State Geologist for 1910.
Bulletin No. 5. Clays of West Tennessee, by Wilbur A. Nelson (in press).
Bulletin No. 6. Road Building in Tennessee, by Geo. H. Ashley (in preparation).
Bulletin No. 7. Water Resources of Tennessee, by L. C. Glenn (in preparation).
Bulletin No. 8. Utilization of small water powers in Tennessee, by J. A. Switzer and Geo. H. Ashley (in press).
Bulletin No. 9. Economic Geology of the Dayton-Pikeville Region, by W. C. Phalen (in preparation).

Bulletin No. 10. Studies of the Forests of Tennessee.
  A. An Investigation of the Forest Conditions in Tennessee, by R. Clifford Hall (in press).
  B. A Study of the Growth of the Second Growth Hardwoods, by W. W. Ashe (in preparation).

Bulletin No. 11. The Marbles of East Tennessee, illustrated with colored plates, by C. H. Gordon (in preparation).

Bulletin No. 12. Preliminary Report on Copper Deposits of Polk County, by W. H. Emmons (in preparation).

In appendix "C" are given copies of the press bulletins issued in connection with the distribution of the bulletins so far issued. They are given in this report to give a synopsis of those bulletins.

FIELD WORK.

How Conducted.—The manner of conducting field work has been quite fully explained in Bulletin 1-A, pages 27 *et seq.* Briefly the main part of the field work will consist of a personal, detailed study and mapping of the State's various resources, in the field, mile by mile, to determine the position, character, quality and quantity of each resource, soil, rock formation or other subject of study. This work, to obtain facts of value that will be thoroughly reliable, will require, in most areas, the work of one man for two months for every one hundred square miles studied. That rate assumes the existence of adequate topographic maps on which to work. On account of the cost of such work the cooperation of the U. S. Geological Survey has been obtained, as far as possible, in its prosecution, and that Survey has indicated its willingness to cooperate in such work. Two hundred and fifty square miles in Rhea, Bledsoe, Van Buren and Cumberland counties were so surveyed this past year. After the first year or two it is hoped to increase the areas covered each year. For the first year or two much of the field work will have to be of a reconnoissance nature, necessary for the preparation of preliminary bulletins to meet the need of immediate information. In addition the State Geologist has made many special trips to investigate special conditions, reported occurrences of new materials, etc., etc. In addition to the regular field work on geological and related subjects, the Survey had cooperated in the preparation of topographic and drainage maps and studies. In this work again cooperation has been had with the U. S. Geological Survey and other bureaus.

The primary object of the Survey is to obtain and give information. This can be done most efficiently by obtaining the information through carefully planned work carried on systematically to a definite conclusion and the results then carefully digested and published in as great detail as possible. But in the beginning of any work, such as that inaugurated by this Survey, the need and demand for immediate information make it necessary to spend much time in obtaining and disseminating general information, delaying for the time being the prosecution of the detailed, systematic work. Where, as in this State, a large amount of previous geologic work has been done, much of this desired general information can be obtained from the published reports of that work, though in nearly all cases it has been found necessary to supplement such information with some field examinations. Accordingly a large part of the work of the Survey for the first year has been absorbed in general preliminary studies of the State's resources, and the preparation of preliminary and general papers on those resources.

Cooperative Field Work and Study.—Since May 1 cooperative agreements have been entered into with the Geological Branch of the U. S. Geological Survey for detailed work in the coal fields of Tennessee, the area surveyed being the Pikeville special atlas sheet in Bledsoe, Rhea, Van Buren and Cumberland counties; for a preliminary study of the oil and gas deposits of the State. In addition that bureau has had work in progress in the copper district of Polk County, the preliminary results of which have been kindly placed at the disposal of the Survey. The U. S. Survey has also carried on some general studies in accordance with its usual custom, and the results of such studies redound to the benefit of the State. The Topographic Branch of the same survey has cooperated in topographic work in West Tennessee, and has done some work independently in Middle Tennessee and East Tennessee. The Water Resource Branch of the U. S. Survey has cooperated in a study of the water resources of the State, by Prof. Glenn. The Survey has cooperated with the U. S. Department of Agriculture through its Division of Drainage Investigations of the Experiment Stations, the Bureau of Soils, the Bureau of Public Roads and the Forest Service.

In addition to the bureaus with which cooperative agreements were made, much information has been furnished by other bureaus of the National Government, and by other departments of the State Government. In all cases requests of the State Survey for cooperation or for information have been met more than half way.

Field Work in 1910. *By State Geologist.*—The State Geologist has visited the parties engaged in the several lines of work in progress, spending from two days to a week or more with each party.

He has made independent trips to nearly all parts of the State, examining deposits and getting specimens and photographs. He has attended farmers' conventions in East and Middle Tennessee, a miners' convention in Knoxville and a good roads convention in the same city, the Southern Conservation Congress in Atlanta and a conference with the State Geologists of other States, and with the officials of the federal bureaus in Washington. The preparation of the several preliminary reports (Bulletins 1-A, 2-A, 2-B, 3-A, 4 and 6) and the necessary proof-reading and other matters connected with their publication, has prevented his giving as much time to the field work as he hopes to be able to give after the completion of these bulletins. As stated elsewhere, the preparation of these bulletins has been urgently needed to save time in answering correspondence and supplying information.

Stratigraphic and Structural Geology.—A knowledge of the stratigraphy and structure of the State is fundamental to a study of its economic geology. Taking advantage of the work in those subjects previously done, an outline statement of those subjects for this State was early prepared and included in Bulletin 2-A. No larger studies of the stratigraphy and structure of the State were undertaken this year, though several trips by the State Geologist, David White and others, had for their primary object the securing of data on those subjects. Independently of the work of the State Survey, studies of the Silurian fossils were made by Mr. Ray Bassler, of the U. S. National Museum, and of the Tertiary plants of West Tennessee by Edward W. Berry, of the U. S. Geological Survey, and of the fossils of the Pikeville region by Mr. T. E. Willard, of the U. S. National Museum.

In addition to these special studies all of the economic work has necessarily involved more or less study of the stratigraphy and structure of the region under study. As one of the first things necessary in connection with the successful prosecution of the work was to learn what was known about the geology of the State and its resources, a card catalogue of all reports and papers, dealing with the geology of the State, has been prepared, and from these Miss Cockrill has prepared a bibliography of the State as far as these subjects go, which is now in press.

Coal.—It was hoped when the Survey started that Prof. Glenn would devote the major part of the summer to a reconnoissance study of the coal field of the State, as he was already familiar with many parts of that field. The completion of some work in Kentucky, upon which he has been engaged for several years, however, required the whole summer, and he was not able to give any of the summer to the work in this State. Detailed work in the coal field was done in cooperation with the U. S. Geological Survey in what is known as the "Pikeville Special" quadrangle. This comprises the southeast quarter of the old Pikeville topographic atlas sheet of the U. S. Geological Survey series. An up-to-date topographic map of the region surveyed was prepared only two years ago, and on that basis Mr. W. C. Phalen, assisted by Mr. Henry G. Hart, made a detailed map of the formations and coals and a study of the stratigraphy, structure and economic geology of that region. A preliminary report on the economic geology is being prepared by Mr. Phalen and will be published by the Survey during the coming spring. In addition, the State Geologist is preparing a preliminary report on the coal field as a whole, using such data as was obtained by Safford, and by the U. S. Geological Survey in connection with its folios covering that territory, supplemented by additional information in the field and by correspondence.

Partial arrangements have been made with the U. S. Bureau of Mines for a cooperative study in the use of coal, looking primarily to its more efficient use, but having in view as secondary results the obtaining of facts that may have a large bearing on the smoke problem of the cities of the State. It is hoped the study may be started in January.

Iron.—It had been hoped to undertake a detailed study of the iron ore resources of the Chattanooga district in cooperation with the U. S. Geological Survey and the Chattanooga Chamber of Commerce. Conditions, however, made it necessary to postpone that work until 1911, when it is hoped that such a study may be undertaken and also a study of the iron resources of western Middle Tennessee. Samples of iron have been collected from many parts of the State and Prof. Jarvis, of the University of Tennessee, is engaged in a preliminary field study of the iron resources of the State. His report will be published during the spring.

Marble.—As stated elsewhere a very handsome exhibit of the marbles of the Knoxville district was shown at the Appalachian Exposition, and Prof. Gordon has prepared a short bulletin describing the occurrence and character of those marbles. He also has in progress a more detailed report on the marbles of East Tennessee to be illustrated with plates in color showing the actual appearance of the marbles now on the market. The marble producers have cooperated in the preparation and expense of those plates. As fine marbles are reported from many parts of the State, it is hoped in the near future to undertake a systematic examination of all such deposits as seem to offer commercial building stone.

Oil and Gas.—In cooperation with the U. S. Geological Survey a comprehensive preliminary study of the oil and gas resources of the State was made by Mr. M. J. Munn, of the federal bureau. This included a visit to nearly all of the counties of Middle and West Tennessee. Information was obtained in regard to all wells drilled for oil or gas that could be learned of. A preliminary report on those resources in this State forms Bulletin 2-E.

Phosphate.—Aside from some preliminary studies on the phosphate field, the principal work done has consisted in a detailed tracing of the horizon of the blue phosphate through Williamson County, by Mr. John H. Agee, and the collection and examination of specimens of the phosphate bed, wherever exposed. In addition, Mr. Lucius P. Brown, who has had many years' experience, both in the field and laboratory with Tennessee phosphates, has in hand the preparation of a preliminary bulletin on that subject. As some additional field work is still needed, the appearance of that bulletin will be delayed until late in the spring.

Zinc.—Though no field work has been done by members of the Survey on the zinc deposits of the State, advantage has been taken of the knowledge of that field by Mr. S. W. Osgood to have a preliminary bulletin prepared by him on the industry in this State.

Clays.—Mr. Wilbur A. Nelson has spent most of the fall in a fairly detailed study of the clays and clay resources of West Tennessee. These clays are now being extensively shipped north and east for use in a variety of high grade clay products. Mr. Nelson has collected samples of most of the clays as well as samples of the wares being made in that section. In addition, the several outside companies using Tennessee clay have contributed samples of the ware made by them, which with the clays collected by Mr. Nelson, are now on exhibition in the Geological exhibit. A report on the results of this work will appear during the spring. In addition, considerable attention has been given to the clays found in Middle and East Tennessee. It is hoped that by another season a systematic study of the clays of Middle Tennessee may be undertaken similar to that carried on this year in West Tennessee.

Copper.—The U. S. Geological Survey recently completed a large scale topographic map of the copper district of Polk County. During 1910 Mr. W. H. Emmons, of that Survey, has been engaged in a close study of the geology and resources of that area. Through the liberality of the Federal Survey, the State Survey hopes to be able to publish a preliminary economic paper, giving the results of Mr. Emmons' study.

Drainage Reclamation.—Probably the most important single piece of work done by or under the auspices of the State Survey has been in connection with the drainage reclamation of the little river bottoms of West Tennessee. At the time the Survey started drainage surveys were in full progress in Obion County. Two drainage districts in Gibson County had filed petitions for surveys and organization, and districts on streams in that and other counties had or have since taken the first steps toward the formation of such drainage districts. In cooperation with the Drainage Investigations Division of the U. S. Department of Agriculture, a preliminary study was made of the conditions on the Rutherford Fork of Obion River and on the North and Middle Forks of the Forked Deer River. This work was done by Messrs. A. E. Morgan and S. H. McCrory, drainage engineers from the federal bureau. Upon the completion of their work a report with recommendations was filed, which was printed by the Survey. Following that an arrangement was made with the U. S. Geological Survey for the topographic mapping of the river bottoms. As it was necessary in connection with such mapping to obtain accurate lines of levels and of horizontal control, and as such levels and control would be necessary and of value to all proposed drainage districts in Obion, Weakley, Gibson and adjoining counties, a cooperative agreement was made with the U. S. Survey to extend a net work of levels over all of that territory to which later the drainage surveys of the immediate river bottoms would be tied. This work occupied most of the summer, and was sufficiently completed by October 1, so that topographic parties could take up the work in the river bottoms. Such work was completed on the Rutherford Fork of the Obion River in Gibson County, and on the North Fork of the Forked Deer River in Gibson County. It is probable that by another season similar surveys will be requested on the Middle Fork of the Obion River in Weakley County, the Middle Fork of Forked Deer River in Gibson and Crockett Counties, and the North Fork of Forked Deer River in Dyer County as far down as Dyersburg. With the beginning of the rainy season, late in December, cooperation was again had with the Drainage Investigations Division for a study of run-off, sand wash and other problems, data upon which will be necessary to complete the engineering plans for the reclamation of these valleys.

Water Resources.—In 1903 and following years, Prof. Glenn, Associate Geologist of the Survey, made a detailed study of the underground water resources of West Tennessee, which was published by the Water Resources Branch of the U. S. Geological Survey. At present Prof. Glenn is engaged in extending that study in a less detailed way over Middle and East Tennessee. This study will take some time, but it is possible that a report may be prepared early in 1911. This will include a study of present sources of water supply, possible sources of water supply, water power and mineral springs.

Road Building.—A beginning has been made in the study of road-building materials, and of the conditions affecting road-building in various parts of the State. Some of the quarries have been visited from which road material is obtained, samples and photographs have been gotten, and some studies made on the wearing and other qualities of completed roads using these materials. A bulletin on the building of the roads in Tennessee is in preparation.

Forestry.—Among the duties assigned to the State Geological Survey by the General Assembly in the bill establishing that Survey is the following: "An investigation of the forests, . . . with special reference to their conservation and development for industrial enterprises." In accordance with this provision, the Geological Survey secured the cooperation of the Forest Service of the U. S. Department of Agriculture, in a preliminary examination of forest conditions in this State, and in a brief study of the rate of growth of second growth hardwood. The object of the preliminary examination which is being made by Mr. R. Clifford Hall is to collect as much information as is possible in the very limited period of time available, with a view to recommending a progressive forest policy for the State. A statement of the conditions found and recommendations made is given in Appendix A.

The study of the second growth hardwoods, which is being made by Mr. W. W. Ashe, is taken as an example of the scientific investigations that should be carried on by the State in order to get at facts of value in managing timber lands on a conservative basis. As usual in such cooperative agreements, the Forest Service pays one-half the cost of this work, and the State Survey publishes the reports, which should be ready to be issued in April.

On the following page is given a table, showing the expenditures by the Survey between May 1, 1910, and December 19, 1910, a period of seven and a half months.

FINANCIAL STATEMENT.

CLASSIFICATION OF EXPENDITURES BY THE TENNESSEE GEOLOGICAL SURVEY FOR THE FISCAL YEAR ENDING DECEMBER 19, 1910.

	SALARIES			Equipment	Supplies	Field Expenses and Travel	Printing and Engraving	Service	Total
	Office	Field	Drafting						
Nashville office				$ 221 43	$339 15		$285 10		$ 845 68
Administration	$ 616 62	$ 75 00				$ 91 90	5 25		788 77
Bureau of Information	700 00								700 00
General studies	150 00	95 00							245 00
Preparing Bulletin 1-A	225 00						104 50		329 50
Bibliography	75 00								75 00
Mineral resources	181 50								181 50
Coal work, general	100 00		$ 31 10						131 10
State maps			25 00						25 00
State exhibit	167 50			644 50					812 00
Library				36 00					36 00
Knoxville office and work	706 00	50 00	7 25	39 01		67 00			869 26
Field work				524 11			5 25		529 36
Drainage work	112 50	790 00				814 36	243 80		1,960 66
Pikeville areal work		255 00				92 64			347 64
Oil and gas work			144 50			166 87			311 37
Phosphate work		88 07				167 20			255 27
Clay work		81 00				112 96			193 96
Forestry work						157 00			157 00
Iron work						37 04			37 04
Zinc work							50 00		50 00
Postage								$125 00	125 00
Telephone								36 80	36 80
Transportation of property								42 00	42 00
Miscellaneous								20 55	20 55
Total	$3,034 12	$1,434 07	$207 85	$1,465 05	$339 15	$1,706 97	$693 90	$224 35	$9,105 46

The above table shows the expenses of the Survey practically to December first. In addition to the amount shown there will be the usual expenses of the Survey during December, including expenses for several parties still at work in West Tennessee, but the principal additional expense, which it is estimated will take up all of the remainder of the first year's allotment or more, will be the engraving of maps and printing of the reports now being prepared.

In addition to the amount shown above as expended by the State Survey, the figures at hand show that the cooperating bureaus have already expended over $6,000 and will expend much more before the completion of the cooperative work now in progress. It may be safe to say that the cooperative work in Tennessee will have cost the cooperating surveys close to $10,000, if not more, so that when all of the work now on hand has been completed and published the Survey will have had the benefit of $25,000 worth of service.

PROGRAM AND RECOMMENDATION FOR 1911.

In planning field work from season to season regard is paid to two factors—first and foremost to the body of requests for information along any given line, and, second, information obtained about resources that would seem to offer opportunities for development. Thus, there is hardly a day that does not bring at least one request for information about the coal fields of Tennessee; therefore, any plans should evidently include work on the coal fields in order to obtain the information necessary to answer these inquiries. As an example of resources that may prove of large value, it is known that the horizon of the famous Bedford oölitic limestone of Indiana runs through Tennessee. This stone is probably more used as a building stone than any other stone in the United States. At present Tennessee is using large quantities of that stone obtained at Bowling Green, Kentucky. But it is reported that the Bowling Green quarries are nearing commercial exhaustion. The locating and describing of good stone at that horizon in Tennessee would therefore possibly lead to the establishment of a large new industry in this State.

Based on the two factors just mentioned the following are some of the lines of work for which there appears to be more or less urgent demand.

FIELD WORK ON FUELS.

Coal.—(a) Preliminary reconnoissance survey of the whole field; (b) continuation of detailed study of coal field in Crossville area, based on the new detailed topographic map of the Crossville area made in 1910.

Oil and Gas.—(a) Study of conditions in the field of former production (Fentress, Overton and Scott counties, etc.); (b) study of the conditions in southwest corner of State where active drilling is now being done.

Lignite.—Recent work of the Federal Mining Bureau has shown that lignite used in the producer gas engine will yield as much power per ton as the best bituminous or anthracite coal when used in the ordinary steam engine. There are known to be beds of lignite in West Tennessee that might prove of large value to local industries. Their location and value should be determined.

BUILDING MATERIALS.

Marble.—(a) The area of the Hawkins marble of East Tennessee has been mapped by the U. S. Geological Survey, but that Survey made no study of its commercial or economical aspects. The whole of the outcrop should be studied to determine the character of the bed at all points, whether lying so that it could be quarried, etc., etc. (b) There are known to be many other marbles in Tennessee besides the one now being so extensively quarried. They should be examined and mapped.

Oölitic Limestone.—The possibility of locating sites for quarries of oölitic limestone in Tennessee should be undertaken at once. The whole outcrop should be examined to determine the location of high-grade stone and points where it could be economically quarried.

Cement Material.—There have been many inquiries in regard to suitable sites for the location of cement plants. It is known that Tennessee has suitable materials, but much study will be required to determine just where the several materials occur near each other, and under favorable commercial conditions as regards transportation, etc.

Sandstone and Limestone.—Notwithstanding the large use of cement, there is still much demand for sandstone and limestone for structural purposes. The Survey should have information as to where these materials can best be obtained.

Granite.—For certain classes of structural work granite will always be in demand. The granite deposits of Tennessee have never been studied from the commercial standpoint.

Slate.—The slate industry is one of the new industries of this State. Field studies might show deposits of much value.

Clay.—(a) Preliminary study of the clays of Middle Tennessee, similar to that made in 1910 of the clays of West Tennessee; (b) similar study of the clays in East Tennessee.

Shale.—Examniation of shales for use in the manufacture of paving brick, tile, etc.

FERTILIZERS.

Phosphate.—During the past year many specimens of phosphate rock have been sent to the Survey office, suggesting a much wider distribution of the phosphate rocks than has usually been suggested. (a) Reconnoissance study of scattered points from which phosphatic rocks have been obtained; (b) detailed mapping and examination of horizon of the blue phosphate around the north end of the basin in Middle Tennessee. (c) Similar study of the blue phosphate horizon around the south end of the basin of Middle Tennessee; (d) general study of the brown phosphates, with detailed mapping; (e) general study of white phosphates.

Green Sand.—The recent activity of Germany in stopping the exportation of potash has created a large interest in the native potash deposits. The green sands of West Tennessee are known to carry considerable amounts of potash. They should be studied both in the field and laboratory.

METALLIC ORES.

Iron.—Next to the studies in the coal field the iron ores rank second in interest and importance. The following studies should be made in the very near future: (a) Detailed study of iron ores of the Chattanooga district (in cooperation with the U. S. Geological Survey and Chattanooga Chamber of Commerce); (b) general study of the iron ores of the western part of Middle Tennessee; (c) general study of the iron ores of the eastern part of East Tennessee. It will be necessary in some of this work to supplement the ordinary field work with some prospecting.

Zinc.—East Tennessee has extensive belts of zinc-bearing rocks. A great difference of opinion exists as to the exact extent and value of those deposits. They should be thoroughly studied and their exact value determined as well as can be done without actual prospect drilling.

Lead.—Many undeveloped lead prospects are known. These should be examined to determine if any of them are of value.

Gold.—Much interest has recently been aroused in the possibility of finding gold in Tennessee. The known gold fields of the State should be studied to determine their extent, probable future value, etc.

There are many other metallic ores, such as bauxite, pyrite, manganese, etc., that should be studied in the near future.

MATERIALS USED IN THE ARTS.

Barytes.—The deposits of barytes should be mapped and their value determined.

Fluorspar.—Fluorspar is known to occur at many points in the State. These should be studied to determine if any of the deposits are of commercial size and value.

Glass Sand.—Glass sands are doubtless abundant in this State. Their position and value should be determined.

Paint Materials.—There is a variety of paint materials in the State—ochres, oxides of iron and zinc, etc. Deposits of these should be examined to determine their extent, quality and value.

ROAD MATERIALS.

The State is at present making great strides in the building of good roads, and is doubtless to do much more in the coming years. That the best and most economical results be obtained, definite information should be had of the nearest available materials, of their relative value, of how best used, etc. To determine all these matters with certainty will require much study, and that study should be undertaken at once.

SOILS.

Soil Surveys.—The study of the soils of this State is one of the largest objects before the survey. The immediate work should be a general study of the soils of the State, and detailed studies of the soils of selected areas, including studies as to their use, the special treatment they need, the crops to which they are best adapted, etc., etc. The detailed work will be undertaken in cooperation with the National Bureau of Soils.

Hillside Wash.—Preliminary studies should be made of the causes and remedies of hillside washing.

WATER RESOURCES.

Underground Waters.—Studies of the underground water resources of (a) Middle and (b) East Tennessee, similar to that already made by Mr. Glenn in West Tennessee.

Water Powers.—The bill providing for the establishment of the Appalachian Park, recently passed by Congress, required the examining of the territory involved, by the U. S. Geological Survey before any lands are purchased, such purchases being upon its recommendations. In a recent conference with Mr. Leighton, Chief of the Water Resource Branch of that Survey, it was learned that if the State were prepared to cooperate in that work in the near future, it would be possible to obtain information desired by the State on its water powers, etc., at probably not more than one-third to one-fourth of what it would cost the State to do the same work by itself. It would seem wise, therefore, that the State Survey should be prepared to cooperate to as large an extent as may be necessary in order to take full advantage of this opportunity now before it. Such a study should include stream gauging, to determine the largest, smallest and average flow of water in the many streams, surveys to determine the fall of the streams, where the fall is greater, where suitable sites exist for the location of dams, the probable amount of power obtainable at the different seasons of the year, etc.

Drainage.—The experience of the year just passed in the drainage reclamation of the stream valleys of West Tennessee has shown the need of engineering assistance, and supervision by the State. It has been apparent that the Survey should have one or more thoroughly trained drainage engineers, who could study the special problems involved, who could confer with the engineers in charge of the several districts to insure that plans made by them are adequate for the purposes intended, and that such plans, when carried out, will not affect adversely those owning lands in other drainage districts on the same stream, and who could, in special cases, be designated by the county courts to have supervisory charge of drainage projects, when so desired by the petitioners for any drainage district. In such a case, they would serve as the engineer required by law, thus giving small drainage districts the benefit of a thoroughly trained engineer as well as the large districts, that are large enough to employ a competent engineer.

FORESTRY.

The passage of the Appalachian Park bill by the United States Congress, opens a new chapter in the forest development of the southern United States. Among other things the bill provides a definite sum to be used by the Secretary of Agriculture to cooperate with the several States in preserving the forests from fires, etc., and calls on the States for cooperation to such an extent that it would seem desirable that this State organize a special bureau to handle that work. Furthermore, while the State Geological Survey will gladly continue such studies of the forests of the State as are now in progress or have been made during the past year, it is felt that the magnitude of the lumber and timber interests in this State warrant a larger recognition from the General Assembly, and I would therefore recommend that, without cutting into the other appropriations just named, the General Assembly provide for the establishment of a distinct bureau of forestry. The needs in this case and a fuller explanation of the recommendation is given in Appendix A, in a statement prepared at my request by the U. S. Forest Service after a preliminary study of the conditions made in this State.

In brief, the recommendation is made that there be created a board of seven (7) members, in part, state officers *ex officio*, and in part, practical lumber men; the appointment of a State Forester. The recommendation suggests the authority and duties of the board and State Forester, principally by the transfer of powers and duties conferred by the present law to that board and provides a definite appropriation to make effective the purposes of the act, and suggests coöperation by the counties, both physically and financially.

EDUCATIONAL BULLETINS.

In addition, if time and money will permit, there are planned four educational bulletins, describing the general, physiographic and economic geology of the four principal divisions of the State, including (1) the valley of East Tennessee, (2) the Cumberland Plateau region, (3) the basin of Middle Tennessee and Highland Rim, and (4) West Tennessee; and in particular the geology and economic development around (1) Knoxville, (2) Chattanooga and Sewanee-Monteagle region, (3) Nashville, and (4) Memphis. Those places are chosen partly because they are centers of population, and partly because of the large numbers of visiting students and teachers. Thus, at Knoxville in addition to the University, the summer school is attended by about 2,500 teachers from all over the State; Monteagle is attended by many thousand teachers and others, and Nashville is reported to give instruction each year to over 10,000 visiting students.

These bulletins will not only illustrate the geology of the areas mentioned, but will also show the extent and manner of using the resources of those regions, thus serving not only for the instruction and entertainment of those residing or attending there, but furnishing data for the information of those living elsewhere, who may be seeking to know more about Tennessee.

TOPOGRAPHIC MAPPING.

So long as the work of the State Geological Survey is of a preliminary reconnoissance nature, it can use such maps as are available, supplemented by compass meanders and other rough surveys where no maps exist. Such maps will necessarily show only the large features. For the detailed studies, which it is proposed to undertake, it will be necessary to have larger scale detailed topographic maps.

The following extract from Bulletin 1-A, page 14, explains the value and cost of making topographic maps:

> "The making of maps will form no small part of the work of the Survey. These will range from small scale maps of the State, showing only the county seats, to large scale detailed maps of small areas, showing all of the roads, trails, houses, streams, the exact shape of the hills and valleys, the location of the mines, quarries, springs, etc. Some of the more detailed maps will show every five-foot change of level in the ground. These maps may be published simply as geographical maps for the use of engineers, surveyors, travelers, landowners, prospectors, or other people; or they may form a basis on which are placed facts about the geology, or soils, or timber, the roads, water supply, markets, or any one of those things with which the Survey is to deal.
>
> "High-grade, plain, geographic maps, showing the topography, are much studied and used, where they exist, for the location of steam and electric railways, of State and county highways, of schools, telegraph and telephone lines, for the laying of water pipes, aqueducts and sewerage systems, for the drainage or irrigation of land, for the position of county and township lines, for selecting the best routes for automobile tours or for tramps, in planning maneuvers of the National Guard, in connection with the purchase or sale of land, in gaining exact knowledge of the country, elevation of places, distances and directions between places, and for a multitude of other uses.
>
> "In the early days the geologists made their own maps as they went, and in reconnoissance work that is often still necessary; but where detailed work is to be done, requiring topographic maps on which to publish the geologic results, it has been found much more economical to train men for the specific purpose of map making. To obtain such maps, there is required accurate

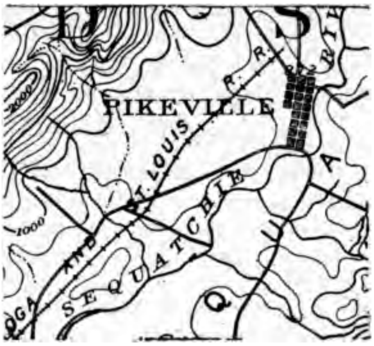


FIG. A. Fragment of Pikeville Topographic Atlas Sheet
Date, 1886-1890. Scale, 1 inch = 2 miles.
Same area as figure B.

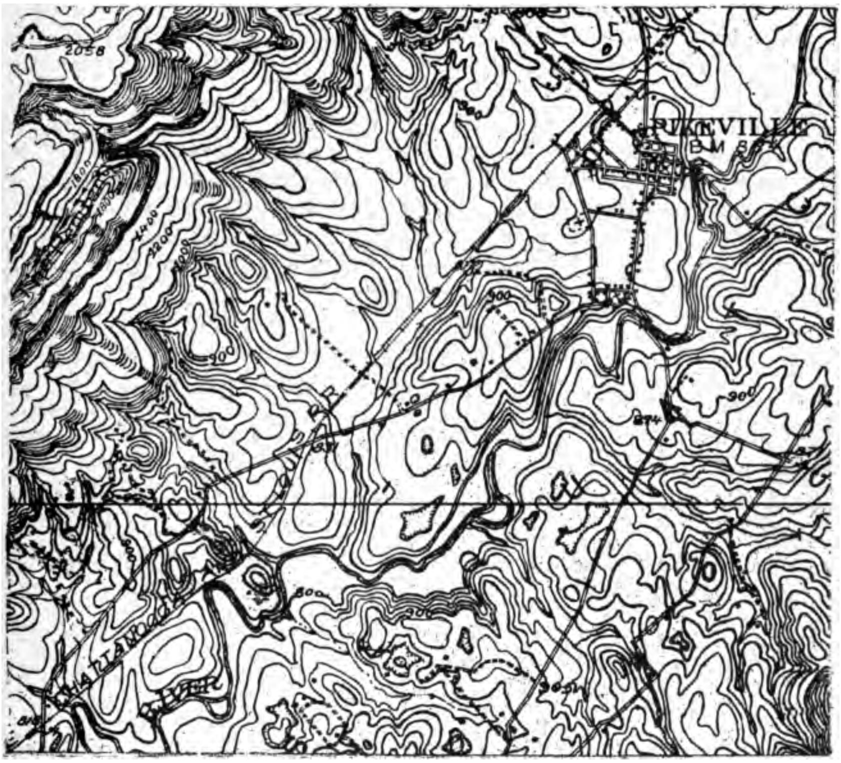


FIG. B. Fragment of Pikeville Special Atlas Sheet
From photograph of field drawing, contours in escarpment west of Pikeville not all shown.
Date, 1908-1909. Scale, 1 inch = 1 mile.
Same area as figure A.

Figures showing contrast between earlier topographic maps (1890) and recent topographic maps. The figures show scale of publication. The area in each is the same.

primary and secondary triangulation, traverses, and leveling work. The preparation of such maps is expensive, costing from $4 to $50 per square mile, according to the scale of the map and the character of the country. It has been the practice of most of the States needing such maps to ask the cooperation of the Topographic Branch of the United States Geological Survey, which stands ready within the limits of its funds to make such maps where requested, the State and National governments sharing alike in the cost of the field and office work, but the National Government assuming the entire cost of engraving and printing the maps. At present forty-eight per cent of Tennessee, mostly in the eastern and central parts of the State, has been covered by such mapping, which, in most cases, has been followed by geologic mapping. The early maps, both topographic and geologic, were done rapidly and at small cost. Gradually the grade of such work has been improving, until today the United States Government frankly labels later editions of the early maps as 'reconnoissance' maps. As the grade of geologic work has risen, it has been found necessary to have better and better topographic maps in order to adequately represent the geologic facts obtained. This has continued until today the older topographic maps are entirely inadequate for the representation of geologic facts as obtained by modern methods. The first step in geologic work has, therefore, been the securing of adequate topographic maps.

"Fortunately, for the beginning of the new work in Tennessee, a few of such up-to-date topographic maps have been made in this State within the last few years. The recent topographic maps on hand will suffice for the geologic work for the first season or two, but soon active steps must be taken to secure similar good maps of other areas on which the Survey desires to do work. Efforts to secure additonal modern topographic maps in Tennessee by the United States Geological Survey will be made.

"The present funds of the Geological Survey of Tennessee do not warrant seeking such cooperation, except to a very limited extent. It is hoped in the future that more funds will be available for that specific object."

The difference between the early maps and those at present being made can best be illustrated by taking out a small piece of the old Pikeville topographic atlas sheet and comparing it with the modern Pikeville special sheet, covering just the same area. As will be noted, the scale of the new map is double that of the old, but of even greater importance is the accuracy of the new map, and the amount of detail shown. It will be noted that the part of the new map shown is from a photograph of the field drawing, and therefore, does not always represent all of the contour lines as the complete engraving will do. The engraved lines will also be finer than those of the photograph from which the cut is made.

A comparison of the two maps will readily show the difference in the possibility of locating one's self with accuracy.

Aside from the gradual resurveying of that part of the eastern part of the State which was surveyed in the early days of that work much of Middle and all of West Tennessee remains to be mapped. As the State Survey desires to do a large amount of detailed work in both of these subdivisions of the State, it is going to be necessary to delay such work until such maps can be made.

During the past year $2,000 of the Survey's funds were devoted to the inauguration of topographic mapping in West Tennessee. From what was stated in the preceding paragraphs, it is evident that much more must be set aside for that work if the mapping is to keep pace with the future needs of the Survey.

DISCUSSION OF PRECEDING PROGRAM.

It is a general belief that in the decade beginning with the year 1911, the whole South is going to make a greater advance than ever before in her history, and many believe a greater proportional advance than any other section of the nation. As Governor Woodrow Wilson expressed it at the Southern Commercial Congress at Atlanta, recently, the South is tense with unused power and strength waiting for the word go; and all over the South the word is being given. In the cities millions of dollars are being spent in improvements that will put them on a par with any cities of the world in matters of health, education, streets, lighting and safety, and hundreds of thousands of dollars are being spent by the cities in learning of their resources and advertising them to the nation and to the world. Nor are the cities of this State behind in this matter. Memphis is spending $50,000 a year in national advertising. Nashville has just decided to increase her advertising fund from $100,000 to $200,000. It required a two-page pamphlet to merely list the new enterprises, enlargements and improvments in Bristol, as the result of a six months' campaign. Chattanooga and Knoxville and other cities are using the same methods with the same results—a large increase in industrial plants, the raising of the value of real estate, a gain in population and all of the attending advantages.

In this forward movement, the States are also going to take an active part. During the ten years from 1900 to 1910, Tennessee stood next to last of the Southern States in advancement as expressed in the gain in population. That standing should not be repeated in the ten years just beginning, but if it is not to be true for the coming ten years, the State must do just as any business firm or corporation would do—learn her resources and advertise them as do other States. The State Geological Survey is peculiarly the agency for doing that work.

In preceding paragraphs there have been outlined suggested lines of work. This is only the beginning of work that must be done before the State will know the extent and value of her natural resources. But to do the work outlined in those paragraphs adequately, and with such accuracy as to warrant definite assertions, would require not less than $100,000 a year, in fact it may be doubted if the present allotment for the Survey work would pay for the printing and distribution of the reports when prepared.

In view of these facts, in view of the unequaled resources of this State, in view of the conscious effort on the part of all of the States of the South to advance their physical development, in view of the fact that this State has been behind all of the other States in acquiring knowledge of her own resources, and in view of the opportunity now before the State, I recommend that for the work of this Survey a sum of not less than $25,000 a year be appropriated to be immediately available in addition to any balance that may remain from the present appropriation. In this connection it should be remembered that even with $25,000 a year it will not be possible to do more than one-fourth of the work outlined in the program given in preceding pages. With such an appropriation, however, it would be possible to more adequately meet the pressing demands now being made on the Survey for information that should lead to the State's advancement.

APPENDICES.

In the preceding pages have been given a brief resume of the work of the Survey for the partial year of 1910. In the following pages are given in less condensed form: (a) A statement relating to the future forest policy of the State; (b) samples of press bulletins describing some of the work and some of the results of the Survey's work; (c) two addresses, describing the relation of the Survey to the coal men and to the farming interests of the State; and (d) descriptions of two exhibits prepared by the Survey.

APPENDIX A.

As a result of a cooperative study of the forest conditions in Tennessee, and at the request of the State Geologist, the U. S. Forest Service have prepared the following statement of the conditions found in this State, and have made certain recommendations for strengthening the present forest law:

(Statement of the U. S. Forest Service.)

The field work on the examination of forest conditions in Tennessee was begun the first of November, and has been carried to such a point that the chief needs of the State in regard to forest legislation are apparent. Therefore it is deemed advisable to prepare a brief preliminary statement as a part of the administrative report of the State Geologist.

The recent movement for the conservation of natural resources has brought to the attention of all thoughtful men the evils resulting from too great a depletion of the timber supply. The loss from this cause would be especially heavy in Tennessee, where the wood-using industries are of great importance and value. In addition to the immense annual lumber production (1,224,000,000 feet in 1909), the large output of hewed ties, posts, mine timbers, wood, tan bark, and miscellaneous forest products adds enormously to the wealth of the State. Many large factories of various kinds, dependent chiefly on local wood supplies, afford profitable investment for capital and a good livelihood for thousands of workmen. The mountainous districts of the State, in particular, depend on the forests, and if the forests are destroyed, there is an impairment or destruction of one of their chief sources of income—practically the only source where coal or other minerals are lacking. The protective value of the forests located on the headwaters of streams in regulating the flow of water is also well understood, as well as their scenic value in making the country more attractive as a summer resort, and benefiting those who come from the cities of the State for recreation or health.

In twenty years, practically all of the timber that is now either virgin or lightly culled will be cut over. A few large manufacturers claim a supply for their sawmills that will last thirty to forty years, but these cases are exceptional. Even now there are no virgin tracts of any extent outside of six or eight counties, most of which are on the North Carolina line. A large part of the timberland now being lumbered consists of small bodies previously culled of the high grade trees, and the operations are usually by small portable sawmills. Consumers of high-grade stock, such as manufacturers of tight staves, of hubs and spokes, and of furniture, report a growing scarcity of timber suitable for their purposes. All indications point to a continued supplanting of higher grade timber with lower grades, as far as this is possible, and to a period of scarcity and greatly restricted production in the not far distant future.

The exhaustion of the virgin timber, however, is not in itself a disadvantage. It is even necessary that mature and decadent timber be cut to prevent loss and to allow younger trees room for development. The great evil lies in the fact that little or no attention is paid to securing a valuable second growth. There is a great deal of land in the rougher parts of Tennessee that will yield little or nothing in any other crop than forest trees. Yet in the face of the growing scarcity of timber, these lands are being allowed to become unproductive through neglect. If all of the valuable trees large enough to bear seed are cut off and much of the young growth smashed down in logging, it can not be expected that the forest will renew itself with commercially valuable species. If fires are allowed to burn over the ground every year, removing the fertilizing and moisture conserving mat of leaves and litter, and giving insect and fungus enemies a chance to enter the trunks of trees that are too large to be killed directly, it cannot be expected that the young growth will develop rapidly into timber of quality, or that the fertility of the soil will be maintained. If timber lands are to remain in a productive state, they must be treated intelligently. No one expects to grow any other crop without attention, and yet no crop matures as slowly as the forest crop or requires as long a period of time for the rectifying of mistakes in management.

The forest land of Tennessee is practically all held by private individuals, and the greater part of this land will continue to be so held, even if Congress sees fit to establish by purchase a National Forest in the Southern Appalachians. If forestry principles are to be applied in order that the woodlands may continue productive, it must be done by these private owners. Most of them will do little or nothing along this line unless the State shows them the need and advantage, and assists them in using proper forest methods. At the same time, the State should help in giving these landowners protection from fire. There is now a very thorough fire law on the statute books; it provides penalties for setting forest fires carelessly or wilfully, but the machinery for enforcing it needs strengthening. In addition, an educational campaign to show the damage that results from surface fires in woodland is greatly needed and will do more to protect the forests from this danger than any amount of legislation. It is now recognized by many States that it is to their advantage to promote better methods of forestry just as they are encouraging improvement in agriculture. Sixteen States employ one or more trained foresters in such work.

The following suggestions for a State forest policy seem suited to the needs and conditions of Tennessee:

A State Board of Forestry should be created consisting of the Governor, the State Commissioner of Agriculture, State Geologist, State Game Warden, Director of the Tennessee Agricultural Experiment Station, and two timberland owners to be appointed by the Governor, one of whom shall be a manufacturing lumberman. The members should serve without compensation except for necessary expenses. This board should direct the promotion of the forest interests of the State and should employ to this end a State Forester. He should be a graduate of a reputable forest school, and a man of experience and ability in his profession. His duties should include (1) educational work, such as the giving of lectures on forestry and related subjects before Farmers' Institutes and other public meetings, and the publication of bulletins; (2) the conducting of scientific investigations with a view to increasing the knowledge of the forest resources of the State and to finding out the methods of forest management best suited to local conditions in different sections; and (3) the administration of State forests for demonstration and experimental purposes. He should be given authority to assist private owners at their request, by making plans for conservative management of woodlands and advising in regard to the execution of such plans, provided that the applicant in each case pays at least the expenses of the field work that may be necessary. He should be authorized to cooperate also with the federal government or other branches of the State government in scientific investigations when this can be done to the advantage of the State. Authority should be given him to make rules and regulations for the State forests, including the right to sell timber, with the approval of the board. In the case of sales amounting to over $1,000 in value advertisement for bids should be required. The board should supervise and direct all the activities of the State Forester, and make a biennial report to the Legislature showing the nature and extent of the work accomplished.

The forestry law of 1907 provides for a system of fire protection under the office of the State Game Warden, giving the county, special and deputy game wardens the duties of forest fire wardens. They are authorized to take charge of fire fighting, to summon assistance, to inspect railroad rights of way, and to arrest, without warrant, offenders against the fire laws. The law has failed in effectiveness because no provision was made for funds to pay the expenses of fire fighting. Also no arrangement was made for posting warning notices, and therefore few people are acquainted with the provisions of the law. It is believed that better results would be obtained by not trying to burden the game wardens with this additional work which has little relation to their regular duties, and for which they may or may not be fitted. Therefore it is recommended that the State Forester be made State Fire Warden, and that he be empowered to request the Board of Supervisors of each county to appoint, with his approval, a county fire warden, or to appoint one himself should the county board fail to take action. The county wardens should be subject to removal by the State Forester. The powers and duties conferred upon the game wardens by the law of 1907 should be transferred, with some modifications and additions, to the fire wardens thus provided for, who should likewise be given the powers of sheriffs in enforcing the forestry laws of the State. The county wardens should also be required to report, on suitable forms, each fire to the State Forester; to post warning notices; and to patrol in danger seasons if directed to do so by the State Forester. If the State Forester deems it advisable, deputy wardens should be appointed by the county warden, with the approval of the State Forester, to work under his direction with the same powers and duties.

The forestry law of 1907 authorizes the State Game Warden to collect statistics in regard to forest conditions, to investigate the suitability of public lands for forest reserve purposes, to take charge of such reserves as might be created, and to accept gifts of land for forest reserves. These duties lie naturally within the province of the State Board of Forestry and should be transferred to that board. The sections in regard to forest reserves should be so modified as to permit the use of mineral land for this purpose, the mineral rights to be retained by the original owner, if the land is acquired by purchase or gift.

The State now owns two tracts of land that would be suitable for forest reserve purposes: the Brushy Mountain tract in Morgan County and the Herbert Domain in Cumberland and the counties that adjoin on the southwest. The Board of Prison Commissioners, which now controls these lands, has no authority to sell timber or practice forestry. It is recommended that the surface and timber on these tracts be turned over to the Board of Forestry to administer as State forests. Thus an opportunity may be given to start at once valuable object lessons in the practice of forestry, as well as experimental investigations. It would also make it possible to stop the loss now incurred by the State through the decay of over-mature timber which cannot be sold under existing statutes. It is also recommended that the Board of Forestry be authorized to purchase, with the approval of the Governor, land for State forest purposes, at a rate not to exceed $5.00 per acre. This authority would probably not be exercised for the present, at least, owing to lack of sufficient funds at the disposal of the board, but would be desirable in case any small tract is needed in connection with the administration of lands now owned by the State and made State forests in accordance with these recommendations.

The expense of carrying out the forest policy as outlined naturally divides itself into two parts—the cost of the State Forester's office in educational, scientific and administrative work, and the cost of fire protection. The first should be met by a State appropriation of $10,000 per year. This would be supplemented by a State forest fund, into which all receipts from the sale of timber on the forests and fines for violations of the forestry laws would be paid. This fund should be used in the protection, improvement and extension of the State forests, or in emergency cases for fighting fire in a county which has exhausted its annual allowance for this purpose. The cost of the general fire protection system should be shared equally between the State and the individual counties in which the money is spent. This division prevents the placing of too great a burden on the more thinly populated counties, and is perfectly fair since the protection of the forests benefits indirectly the entire State, as well as the individual counties. To secure promptness in payment of fire fighters, the State should pay the accounts and collect one-half from the county in which they were incurred. The rate of compensation for fighting is fixed in the present law at $3.00 per day. This is unnecessarily high, and would be an inducement to set fires in order to get employment in putting them out. It is recommended that the rate be changed to 20 cents per hour and that the county and deputy wardens be paid at the rate of 25 cents per hour for time actually employed in fighting fire, posting notices, making reports, or doing other official work. They should also be reimbursed for reasonable expenses for necessary equipment and transportation. All accounts, including those for wages, should be approved by the State Forester before payment. The amount to be spent for fire protection in any county in any one year should be limited to $200.00 and in the entire State to $10,000 per year. The total cost to the State of the forest policy recommended could not then exceed $15,000 per year, and the cost to any one county could not exceed $100.00 per year, while the maximum total expense per year would be $20,000. This expenditure is to be regarded as an investment, the returns to come in the form of increased productivity of the woodlands, in the saving of loss through fire, and in the maintenance of wood-using industries.

Forest conditions, problems of forest management in the different regions of the State, and questions connected with the carrying out of a State forestry policy, will be discussed in the report, which will be issued soon after the completion of the examination now being made by the Forest Service, and upon which these preliminary recommendations are based. This report will show more fully the need for a definite progressive forest policy.

APPENDIX B.

As the several papers published by the State Geological Survey have been issued at different times, and do not accompany this administrative report, copies are given beyond of the press bulletins issued at the time of their appearance in order to give a synopsis of what they contained.

PRESS BULLETIN NO. 4.

STATE GEOLOGICAL SURVEY ISSUES ITS FIRST BULLETINS.

The State Geological Survey has just issued its first bulletins. These consist of part "A" of Bulletin No. 1, on the establishment, purpose, scope and methods of the Survey, which tells what the Survey proposes to do, and how it will do it and the benefit to be derived from its work, and Bulletin No. 3, on drainage reclamation in Tennessee. Part "A" of Bulletin No. 1, is by the State Geologist. It deals, in a broad way, with the need of a State Geological Survey and the status of such a survey in the economy of the State. It gives the bill under which the Survey of this State has been established, the personnel and the facts connected with its establishment. It then takes up the objects of the Survey, and points out some of the distinct lines of service it may render to the State and to the citizens of the State. Under "Scope of the Survey" its various lines of study are outlined, and an idea is given of the information to be studied, including everything from the setting of meridian lines at the county seats to the study of the smokeless combustion of fuels; from the detailed mapping of the phosphate rocks to the reforestation of the Cumberlands. The inside workings of the Survey are explained under the heading of "Methods." The bulletin closes with a frank statement of the Survey's relation to the public. Bulletin No. 1, part "A," can be obtained upon request when accompanied with necessary postage, two cents.

STATE ISSUES A REPORT ON THE DRAINAGE OF THE BOTTOM LANDS OF WEST TENNESSEE.

The State Geological Survey has just issued Bulletin No. 3, on "Drainage Reclamation in Tennessee." The bulletin contains three papers; the first, on drainage problems in West Tennessee, by the State Geologist, discusses the general problems and benefits involved in the drainage of the river bottoms. It points out that not only today, but all through history, the alluvial flood plains of the rivers have been the richest agricultural lands of all nations, but that to secure the use of these flooded plains, it has always been necessary to protect such lands from the floods, and that when so protected these lands are changed from worthless lands, a constant menace to health, to lands of the highest value. It cites the case of Illinois, where some of the richest lands of the State today were continuous swamps when the State was first settled. The author discusses the question of cost, and of value after reclamation, how funds are obtained, etc.

Some idea of the magnitude of the undertaking is gained from the statement that there are estimated to be 1,000,000 acres, in West Tennessee alone, needing reclamation, and involving an expenditure by the districts involved of from $10,000,000 to $15,000,000, but he points out that when fully reclaimed, the State will have gained practically 1,000,000 acres of the most productive land in its borders, and the lands so reclaimed will have increased in value by probably not less than $50,000,000.

The paper then discusses the present conditions in West Tennessee, the width of the bottom lands, the gradient of the streams, the fact that flooded conditions are growing worse, rather than better. The author points out the distinct problems to be met, the stages of the work of reclamation, the causes of past failures elsewhere, the preliminary data to be collected and how the construction work is to be planned.

The passage of drainage laws in Tennessee, making possible the proposed reclamation is referred to and the special province of the Geological Survey in the work pointed out.

The second paper is by Messrs. A. E. Morgan and S. H. McCrory, drainage experts of the National Drainage Investigations Division of the Agricultural Department at Washington. It is the first of the reports covering cooperative work between the State and National Governments. It describes the results of a preliminary study of the drainage conditions as they exist in Gibson County. The idea of this study was first to determine the feasibility of the reclamation of the stream bottoms of that county, then the factors to be dealt with and their relative importance, to get some idea of the cost and to give general recommendations on the carrying on of the work. The advantage of having the opinion of experts of such wide experience and training can hardly be estimated. It is realized somewhat when it is noted that they report that the plan of construction that has been proposed for the North Fork of the Forked Deer River would not have taken care of more than one-fourth of the average storm waters, of the average year, let alone the abnormal storms, which occur every few years. Also that they report that the plan of constructing side ditches, which has been proposed, would result in quickly choking up the main channels and require their constant cleaning out, or nullify all of the benefits of the reclamation work. The report, which is illustrated with a map, gives a general description of each of the river valleys. It gives detailed figures of the rainfall in that region, making a special study of the more important storms of which there is record, especially of the storms of December, 1902, and November, 1906. It describes the conditions governing the run-off, the side wash, etc., and points out that while control of soil erosion and deposition from the hillsides will not be a very serious problem, it is one which cannot be neglected, and which, if not adequately provided for, will render all the rest of the work of no avail. They suggest methods of controlling the soil erosion either by the use of collecting ditches, or of collecting basins. They discuss the prevention of erosion, etc. Under other headings they consider the possibility of enlarging smaller channels by erosion and discuss in a broad way what constitutes reclamation. In general they recommend that no work be undertaken, which will not insure entire freedom from overflow at least three or four years out of five. They suggest that the very occasional storm, which may on the average come not more than once in ten years, need not be taken into account, though it would be much better were it done. They discuss plans for the improvement, the benefit to be derived, the surveys that it will be necessary to make and close with certain recommendations for the future carrying on of the work.

It may be noted in passing that the detailed surveys of these valleys are to be undertaken in the very near future, and it is expected that additional data on the run-off will be obtained the coming fall, thus securing all of the data necessary for planning adequate construction work.

The third paper of the bulletin is a reprint of the drainage law in the State in this form to be of service to engineers and others interested in the drainage problems of this and other States.

While part of the edition of this bulletin will be bound together in a single volume, another part of the edition of the three papers will be bound separately in order to facilitate their distribution where only one of the papers is desired.

Copies of the bulletin as a whole or of any of the three papers may be obtained upon request from the State Geologist, Capitol Annex, Nashville, Tennessee, upon receipt of the necessary postage. The postage of the bulletin as a whole will be six cents and two cents for each of the three papers.

PRESS BULLETIN NO. 5.

AN OUTLINE DESCRIPTION OF THE MINERAL RESOURCES OF TENNESSEE.

The State Geological Survey has just issued a new bulletin, this time a preliminary paper on the Mineral Resources of Tennessee. This bulletin was prepared primarily to accompany the exhibit of the State's resources being made by the Survey at Knoxville at the Appalachian Exposition. The bulletin deals with the general geology of Tennessee in a very few paragraphs, and then gives from a part of a page to several pages to each of the many mineral resources of the State. The bulletin opens with a general introduction on the State as to its size, location, its favorable situation with reference to markets, climate, etc. In this connection the State Geologist makes the assertion that "with her abundant and varied mineral resources, soils and climate, Tennessee, if cut off from communication with all other States, could continue to supply herself with all, or nearly all, of the needful materials to maintain her present or future civilization. Water power and coal would supply her with power; her iron, lead, zinc, copper, gold, silver, aluminum and other mines would supply her with metals; her building stones, marbles, clays, cement materials and forests would supply her with building materials; the materials used in chemistry and the arts she could secure from her own storehouse, if cut off from outside supplies; and with the exception of tropical fruits, she can raise any food raised anywhere in the United States."

Under the heading of surface features of Tennessee, he states that "it is safe to say that no State in the Union excels it in general attractiveness of physiographic aspect," and gives the reason therefor. A table is given of all of the named rock formations in the State, showing their position in the geological time scale, their correspondence in different parts of the State, and then is given a brief description of each formation. This is followed by an outline history of the State's geology, pointing out the recurring times in which the State has, in part, or whole, sunk beneath the ocean and received deposits of one kind or another, and again been lifted out of the sea and been subject to erosion; he cites the great changes which took place, resulting in the mountains and valleys of the State.

Under the heading, "The Lay of the Rocks," a brief description is given of the way the rocks of the State lie, whether horizontally or in folds, a condition that has a great bearing on the position of oil and gas pools.

The most important part of the bulletin, however, is that dealing with the economic minerals of the State. These are taken up alphabetically, and a brief summary is given of what is now known of their occurrence and character, the ores from which they are derived, their value, etc. Among the many minerals discussed might be mentioned barytes, bauxite, cement, chert, clay and shale, coal, copper, fluorite, gas, glass sand, gold, granite, iron, lead, lignite, limestone, manganese, marble, metallic paints, mineral springs, novaculite, oil, phosphate, silver, slate, zinc and many other less important minerals.

While the report as a whole is simply a digest of what has already been written about Tennessee, much of what has been written is not in available form, and many new facts have been added, some of which have been well known but have not gotten into print, and some of which have been gained by the Survey during the past few months. The section on oil and gas may be cited as a case where the results of a special study the past summer are drawn on. The detailed results of that study will appear later as a separate bulletin.

The paper just issued forms part "A" of Bulletin 2, "Preliminary Papers on the Mineral Resources of Tennessee," and will be followed by parts "B" to "H" containing somewhat longer papers on the coal, oil and gas, marble, iron, phosphate and other resources.

The report can be obtained at the office of the Survey in the Capitol Annex, or by writing to the State Geologist and inclosing postage, two cents.

PRESS BULLETIN NO. 6.

GREAT QUANTITIES OF ZINC ORE IN TENNESSEE ONLY AWAIT CAPITAL FOR THEIR DEVELOPMENT.

Recent developments have demonstrated the possibility of profitable mining the bodies of low grade ore forty to fifty miles long and hundreds of feet wide. The State Geological Survey has just issued a bulletin of less than twenty pages, dealing with the mining of zinc in Tennessee. The paper is illustrated and was written by Samuel W. Osgood, of Knoxville, who has been associated with zinc mining in the Joplin and Galena districts, and more recently in the East Tennessee district. The paper refers briefly to the character and geology of the ore. Then discusses the past history of zinc mining in Tennessee, and points out the causes of past failures. Then it describes recent experimental developments on a much larger scale than had heretofore been attempted with results that lead Mr. Osgood to believe that the profitable development of the ores have been demonstrated.

The ore is of a low grade though higher than the Joplin, Missouri, ore, and Mr. Osgood believes that the key to the situation is simply the working of the deposits on a large enough scale to permit of the use of labor-saving machinery so as to reduce the per ton cost of mining and milling the ore, and he gives the figures upon which his conclusion are based. He also gives figures to show that the smelting of Tennessee ores in Tennessee should prove a very profitable business when properly carried on.

It is only another case similar to the copper situation at Ducktown, where a deposit that could be worked on a small scale only at a loss will yield a handsome revenue if worked on a large scale with proper machinery. The same thing is true of much of the mining operations on the metaliferous ores everywhere today. A large share of the metals are today obtained from low grade ores by the use of up-to-date machinery that could not have been profitably mined a few years ago. It is believed that ultimately Tennessee will be found to possess many other low grade deposits that will be workable only when capital to the extent of at least several hundred thousand dollars is invested in their development.

The bulletin is part "G" of Bulletin No. 2, and is entitled "Zinc Mining in Tennessee." It can be obtained from the State Geologist by inclosing postage, one cent.

APPENDIX C.

Samples of press bulletins, especially prepared papers and addresses to give a more comprehensive idea of the work of the Survey. There are here given three press bulletins, one describing a piece of work just being undertaken, one describing an interesting economic condition that appeared to be worthy of public notice, and the third describing the results of field work, which did not involve publication. As illustrating the type of articles specially contributed may be given one published by the Appalachian Trade Journal, stating the relation of the State Survey to the coal interests; that is followed by an address given before the annual middle division of the Farmers' Institute on the relation of the State Survey to the farming interests. The last two papers have the further advantage of bringing out more clearly than have any of the regular survey publications the work of the Survey as it appears in relation to those two great interests of the State.

PRESS BULLETIN NO. 7.

STUDY OF TENNESSEE'S FOREST PROBLEMS.

Tennessee is one of the largest lumber producing States in the Union. How long will the supply last? Detailed surveys in Kentucky, extending from 1907 to 1909 have shown that "assuming that the *output of the last three years is maintained,* and that growth is balanced by local consumption and damage, the timber supply of Kentucky will last fifteen years." Is Tennessee any better off? Both in Kentucky and Tennessee it is true that absolute exhaustion will never be reached under any condition, because as the supply approaches exhaustion the output will be decreased until it is finally met by the annual growth. But Tennessee does not desire a decreasing output. The lumber interests of Tennessee are today among its largest industries, especially when taken in connection with all of the dependent industries which have come into the State to take advantage of the abundant supply and cheap cost of lumber. Large parts of the State are better suited to the raising of trees than anything else, so that if the lumber industry is allowed to decline, it will not be supplanted by some other more important industry. Its decline would mean a dead loss to the State.

With a growing appreciation of this impending loss, the people are giving more attention to the problems of renewing and maintaining the forests so that the present output may be maintained or increased indefinitely. Since the timber industry must ultimately depend on the growth of the forests, that growth must be increased by every means possible.

In the belief that the first step in the study of the problem is the securing of facts, the State Geological Survey has entered into a cooperative agreement with the National Forest Service for a preliminary study of the present forest conditions of the whole State. The work will be in charge of Mr. R. Clifford Hall, of the Forest Service, U. S. Department of Agriculture, who has recently completed a three-year study of Kentucky, and the results will be published by the State Geological Survey. Although work involving detailed estimates and measurements is not contemplated in this preliminary study, the most important problems affecting forestry in the different sections of the State will be considered. The aim is to bring the general facts before the public in the hope that as a result ample provision may be made for the actual carrying out of active measures, looking to the maintenance of the State's present position as a great lumber and wood-working State.

PRESS BULLETIN NO. 8.

A Gold Mine in Tennessee Clays.

An examination of the clays of West Tennessee, now being made by the State Geological Survey, has already convinced the State Geologist that Tennessee offers exceptional opportunities for the development of a large industry in the manufacture of chinaware, sanitary and porcelain ware of all kinds, glazed and encaustic tile, electric high tension insulators and fire brick, to say nothing of the great number of lower grade products—ornamental, paving, and common brick, terra cotta, roofing and drain tile, domestic ware, etc. At the present time the State produces between one and two million dollars worth of clay products; but most of that is in the form of common building brick. It is in the manufacture of the higher grade products that the State Geologist believes there is room for great expansion.

In the first place the State has the necessary raw materials. At the present time, Tennessee clays are being shipped in large quantities to Kentucky, Indiana, Ohio, Pennsylvania, New York and Connecticut, in many cases supplying the largest part of the raw clay used.

In the second place, south, west and southwest of Tennessee lies a great market at present obtaining its supplies from States to the north and east of that State, the raw materials being shipped from Tennessee to the potteries, manufactured and shipped back again to the State, or through it on its way southwest.

In the third place, Tennessee is well supplied with shipping facilities, both by rail and water.

To take a single illustration: In 1891 a pottery was started in Evansville, Indiana, making semi-porcelain and white granite table wares. It uses ball clay from Tennessee, kaolin from North Carolina and Georgia, feldspar from Pennsylvania and ground flint from East St. Louis. In 1904 the output of that plant alone had grown to an annual value of $220,000 and gave employment to three hundred hands.

Portions of West Tennessee are already dotted with great holes from which clays are being shipped. The clay beds range in thickness from two feet or less to eighteen feet or more, sometimes in solid beds of uniform character, sometimes in a succession of beds of varying character, the individual beds being suitable for distinct uses. Thus, one bed may be especially suited to the making of saggars, the next underlying bed for white chinaware, the next for high tension electric insulators, etc. As a rule the deposits are limited in extent to a few acres, but as a bed of clay ten feet thick and ten acres in extent will yield over 200,000 tons of dry clay, these little pockets in the aggregate could supply a large output, as indeed they are doing at present. As a rule the deposits have a rather heavy overburden amounting, in some cases, to thirty or forty feet, though the average for the pits now being worked will probably not run over fifteen or twenty feet.

Apparently the main obstacle in the past to the location of clay plants in West Tennessee for the manufacture of high grade wares has been the lack of trained labor, and the fact that the nearest coals, those from the west

Kentucky fields, are too high in sulphur. It is probably true that a plant starting in that territory would have to import a certain amount of its skilled labor. As the belt through which the best clays run follows the high divide between the Tennessee and Mississippi rivers—a region of fine farms, prosperous towns, rapid streams, and excellent health conditions, equal in those respects to most parts of Ohio, Indiana or Illinois, the importation of such labor should present no difficulties. The fuel problems may be met by converting the coal into producer gas and washing; by the use of oil from the neighboring Caddo oil field, by the possible use of producer gas from the beds of lignite found in the same region, or by the use of coal from East Tennessee. In the latter case it would require the bringing in of only coal enough for the kilns, as Kentucky coal could be used for power for the mills, etc.

Or the plants could be located at Nashville or some other Middle Tennessee point within easy reach of the ball clay from West Tennessee, the kaolin and feldspar from Georgia (if Tennessee deposits prove insufficient) and coal from the coal field just east of the city. Nashville is naturally a distributing point with both rail and water freight, and already has other large clay interests.

Considering, therefore, that the bulk of the raw materials of all kinds used in the manufacture of high grade clay wares are obtained from the South, it would seem that as much of those wares as may be needed to supply the southern and southwestern market could well be made there.

PRESS BULLETIN NO. 9.

A YEAR'S PROGRESS IN DRAINING THE BOTTOM LANDS OF WEST TENNESSEE.

Now that the season for work in the bottom lands of the little rivers of West Tennessee is drawing to a close, it may be of interest to know what has been accomplished toward their reclamation. It will be remembered that the drainage of these swampy bottom lands first became possible through the law passed at the last session of the State Legislature. Until a short time before that the Supreme Court had held against the principle of local taxation for local improvements; then a decision favorable to such taxation opened the way to such laws as the drainage law. During 1909 initial work was started both in Obion and Gibson counties. In Gibson County a line of survey was run down the North Fork of the Forked Deer River, and a suggested plan of construction outlined. In Obion County an engineer was employed to make a study of the drainage problem in that county, and to report on the feasibility of such drainage.

On receiving a favorable report the people of Obion County employed Mr. P. E. Fletcher, an engineer who has been engaged in drainage work in Illinois, and early in the spring of 1910 surveys were started on the 70,000 acres of bottom land in Obion County. These surveys were completed during the summer, and then an equally difficult task was taken up of disentangling the land lines and tying them to the survey. Because of the almost entire lack of corner stones and the loose methods of describing land lines in the early days, this part of the work took almost or quite as long as the detailed survey. It has recently been completed, and the report of the engineer made. Next will come the period of adjustment, the determination and adjustment of damages, if any, and the classification of the lands and their assessment for benefits; then will come the sale of bonds, and if all goes well next summer ought to see the beginning of construction work. The plans as at present approved include not only the clearing and straightening of the channel of Obion River, but the formation of levees above and outside the channel. At Obion these levees will be ten feet high and fifteen hundred feet apart.

When it is realized that this one project will cost between a half million and one million dollars, some idea of the magnitude of the work may be gathered. On the other hand, when it is remembered that the 70,000 acres in this district, now practically worthless, should be worth fully $5,000,000 when reclaimed, some idea of the value of the work is had.

In Gibson County further steps were delayed pending the inauguration of the State Geological Survey, which had already been provided for. As soon as that organization came into existence, a conference was held at Trenton, and as a result of the plans outlined, the State Survey entered into a cooperative agreement with the Drainage Investigations Division of the U. S. Department of Agriculture. Under this agreement two of the Federal drainage engineers made a thorough preliminary study of all of the factors involved in the proposed reclamation, the special difficulties to be met, the surveys and data necessary to be obtained before planning the work, the cost, etc. The report was published as Bulletin 3-B by the State Survey. Meanwhile the State Survey entered into a cooperative agreement with the Topographic Branch of the U. S. Geological Survey, and ran a net work of accurate primary levels over the area in which drainage work was being undertaken or might be undertaken in the near future, including parts of Obion, Weakley, Dyer, Gibson and Crockett counties. Permanent bench marks were set which would serve as the basis for all of the future survey work.

By October first this work had progressed so far that the surveys of the valley bottoms could be started, and during October two topographic parties were started in Gibson County, one on the Rutherford Fork of Obion River and the other on the North Fork of the Forked Deer River. The work was greatly retarded by the heavy rains of the first part of October, which flooded the stream bottoms in places as high as they had ever been, and required weeks to run off. These parties will complete the portion of the Rutherford Fork of Obion River and the North Fork of the Forked Deer River in Gibson County, and may be able to map the Middle Fork of the Forked Deer River in Gibson and Crockett counties, or the river below the junction of the two forks as far down as Dyersburg. In this detailed mapping the local districts cooperate with the State Survey and the U. S. Geological Survey—the local districts taking much of the financial burden, and the U. S. Geological Survey doing or directing the work. In addition the local districts have employed surveyors to determine the land lines and tie them into the topographic surveys.

Cooperation between the State Survey and the Drainage Investigations Division of the Agricultural Department will become active again in December, when studies will be undertaken of the amount and character of the run-off, and the collection of much other data necessary to the planning of the construction work. These studies will extend through the rainy season. With all of this data collected and the topographic and other surveys completed, the

Gibson County districts plan to employ a thoroughly competent engineer to plan the construction and to supervise it. It is hoped that plans may be made during this winter, as well as the adjustments for damages and benefits, so that contracts may be let in the spring for the work of construction. In addition to the work thus actually accomplished, several districts outside of Obion and Gibson counties are considering taking up drainage work, but only one has taken the initial step. A meeting was held in Sharon, November 12, at which time the land owners along the Middle Fork of Obion River in Weakley County took the preliminary steps toward forming a drainage district. It is hardly probable that surveys can be made in that district this fall, but it is hoped they may be ready to take up work as soon as the valleys are free of water in the spring.

THE GEOLOGICAL SURVEY AND THE COAL MEN.*

With the inauguration of any new enterprise, those whose interests it touches have a natural desire to know what its attitude and program will be in its relation to those interests. What the State Geological Survey of Tennessee hopes to accomplish for the coal men of Tennessee may best be judged by an examination of what those in charge of the newly organized State Survey have been doing for the coal men of this and other States. Most of the operators of the State are already familiar with the results of the work of Messrs. Ashley and Glenn in the Cumberland Gap region of Kentucky and Tennessee, in 1902. Those results were published by the U. S. Geological Survey as Professional Paper No. 49, and distributed, at that time, to all of the coal companies of the State. Briefly, that report attempted to show, by maps on a scale of one mile equals one inch, the line of outcrop of each principal workable coal bed, its position in the hill, and the area underlain by it, and points where each bed was being mined, or was exposed and could be measured and examined. In the text were given many graphic and written columnar sections to show the relation of the different coal beds to each other, or their distance apart and the distance of each below or above any prominent cliff making sandstone or any observable or conspicuous rock. Of each bed there were given from a score to a hundred or more personally measured sections and general conclusions were drawn as to the thickness and partings, extent, irregularity or variability, chemical and physical character of such beds, etc.

While that work may be taken as a fair earnest of what the State Survey will do for all of the coal fields of Tennessee, on the other hand it is hoped for several reasons to secure much more accurate and complete results in the work recently started in this State. In the first place when the Cumberland Gap work was done in 1902, the only topographic base map available was the one made by the U. S. Survey, nearly twenty years before on a scale of two miles to the inch, and with one hundred foot contours and the character of the geologic work was gaged by the character of the base map. The report when published used a new topographic map made in 1903, or after the geologic work had been done. In contrast with that the coal work being done this year in Tennessee is using a new base map on the scale of one mile to the inch, with twenty-foot contours and with a wealth of detail entirely out of reach twenty years ago. In the second place, the work in the Cumberland Gap area was done at a rate of six to ten square miles a day for each man working. The work now in progress in the Pikeville region is covering the ground with about four times as much detail, and necessarily only one-fourth as fast. In the third place, in the eight years since 1902, both Messrs. Ashley and Glenn have had opportunity to study broadly, as well as in detail, the coal fields of many States from an economic and commercial standpoint as well as a geologic.

---

*Published in The Appalachian Trade Journal, for November.

Some of the results obtained in these States by the present State Geologist, or under his supervision, particularly in Pennsylvania, may be of interest. Geologic work in the coal fields by the State and National governments has shown a steady increase in accuracy and detail. At first little was attempted beyond determining the presence of coal and outlining in a general way the boundaries of the coal-bearing rocks. The work of the second Geological Survey of Tennessee, under Mr. Safford, represented about this stage. Later on the attempt was made to show by separate patterns on the maps the position of particular groups of rocks that appear to be more largely coal-bearing. Suggestions may have been made as to the correspondence of the coals at points some distance apart, as indeed was often done in the first stage, but as a rule no attempt was made to show the actual horizontal and vertical position of the coal beds or to trace the outcrop of even the most important coals over the area mapped. This was the stage of progress at the time of the folio work by the U. S. Geological Survey covering the coal field of Tennessee. With larger funds per square mile the ground could be covered more closely, and the actual tracing and mapping of the coals attempted, involving necessarily the exact correlation of the beds from point to point and resulting in the acquisition of a large amount of information about the coal beds themselves. The Cumberland Gap work represented about this stage in the progress.

At the time of the second Pennsylvania Geological Survey, large scale maps were made of the anthracite coal field (which covered less than five hundred square miles) that show not only the outcrop of the principal coal beds, but also by structure contour lines the actual elevation above sea level of some principal bed. Similar structure contour maps, usually covering only a few square miles, were made in western Pennsylvania, and had been made in other States. But the first attempt in this country to do such structure work on a large scale began with the reorganization of geologic work in Pennsylvania about ten years ago. In the recent work the State and National governments have cooperated, each paying one-half the expense, and the National bureau has done the work. In this work an area about twice as large as the whole coal field of Tennessee has been mapped, showing not only the outcrop of the coal beds, but the structure of the rocks and coals, by structure contours with a contour interval of from fifty feet to ten feet. On a map where ten-foot contours are used, it is possible to compute the depth of any coal bed within ten feet; where fifty-foot contours are used, the depth may be computed to within fifty feet. Repeated tests by subsequent drilling and mining have attested the general accuracy of this work. The ten-foot contouring has been possible only under the most favorable conditions.

Such detailed results have been possible only because correspondently detailed maps were being made by the Topographic Branch of the National Geologic Survey. The work of the topographers has increased in accuracy and detail in the same way as that of the geologists. In the recent Pennsylvania work spirit level lines were run over all of the public roads, which in that region are very abundant, and bench marks painted on the fences at least every one-fourth of a mile, besides the many more permanent bench marks that were set. Special levels were also run to all mines and prospects. In Pennsylvania a State law requires that the mine maps show the levels all through the mine. In addition to the levels so acquired, the geologists, who followed the topographers, have constantly used the hand level in running short lines from the nearest bench marks or painted elevations to outcrops of the coals and other recognizable rocks. In this way hundreds or thousands of elevations have been obtained, and on the basis of this the contour lines were drawn.

Coming back to Tennessee, several points may be noted in connection with the coal work of the State Survey. First, some three years ago the U. S. Geological Survey began remapping topographically the Tennessee coal field. This work is being done on the same scale, and with the same accuracy as the work in Pennsylvania, so far as the conditions will permit. Therefore, unless the State Survey is to go to the expense of making such a topographic survey itself, it must confine its operations to those areas already remapped or else content itself with such results as may be possible upon the old "reconnoissance" maps. Another argument lies in the fact that the U. S. Geological Survey has already shown its willingness to cooperate in a geological resurvey of the areas remapped topographically.

In the second place, experience has shown that much better results are secured by continuous tracing of the coals and other rocks than by jumping about from point to point. One or two facts may be cited to show why this is so. For example, starting at Freeport, in Pennsylvania on the Allegheny River, it is possible to trace the upper Freeport coal almost continuously in complete exposure in the railroad cutting for mile after mile down the Allegheny River, the Allegheny at that point following the axis of a syncline and the dip of the rocks is very little more than the grade of the stream. A study of the coal section shows that the coal varies from a thickness of seven feet to nothing, sometimes maintaining its thickness with great regularity, and then where subject to an erosion of carboniferous time, of slightly later date, it is cut out either in part or whole, sometimes for a long stretch. If one were to be dropped down into one of those stretches where the coal and its immediately accompanying rocks were gone, he would be entirely at sea as to the stratigraphic relations of the rocks before him, but having traced the coal continuously from where it has not been eroded, it is possible for him to lay his hand on the rocks and say that had it not been for this subsequent erosion the upper Freeport coal bed would have existed right there. To cite another case from Indiana, the No. III coal of that State had a magnificent development ranging from six to thirteen feet all through Green, Sullivan, Clay, Vigo, Southern Parke and Vermilion Counties. Then the coal gradually thins out, but its horizon can be traced for a great many miles to the northward, possibly clear over into northeast Illinois, just at the top of a very sandy fire clay. Hundreds of other cases might be cited, showing the advantage of tracing continuously, and other cases might be cited of errors that had been fallen into by the other plan of starting work from time to time at separated points.

In the third place, the results in Pennsylvania have only been possible because of the very cordial and complete cooperation of the mining men of that State. The coal companies almost without exception have turned over to the Survey all of their drilling records, coal analyses and many other data of great value in carrying on the work. As a rule but very little of this data has actually been published, and practically always only with the consent of the company that gives the information. As time has gone on the companies have been more willing that data should be published, as they have recognized the mutual advantage that would come to themselves and others by the fullest discussion of the data given.

At this point it ought to be stated that the basis for any assistance that the geologists may render to the individual coal operators is principally in the fact that has been demonstrated by long experience that notwithstanding all the seeming variation of the coal beds, individual beds show marked similarity from point to point, and ***coal horizons*** can often be traced over vast areas. The Pittsburg coal bed of Pennsylvania, Ohio, Maryland and West Virginia used to be pointed to as an illustrious example of a widespread coal bed. With a broader knowledge today we know that many coal beds in the Appalachians and the Illinois field, as well as others, have far exceeded the area covered by the Pittsburg bed. For example, coal V of Indiana has been traced almost continuously from where it enters Indiana in Vermilion County to where it crosses the Ohio east of Evansville. From there it can be traced through a large share of the western Kentucky coal field where it has been designated coal 9. Coming back to the Ohio it crosses into Southern Illinois and from there can be traced entirely across the southern part of the coal field in that State, and is today being traced northward until it looks as though that bed can be actually followed over probably a score of thousand square miles or more. And again, one of the most interesting developments of recent work has been to show that apparently disconnected pockets lie at certain definite horizons and that the same succession of benches can be traced from one pocket to another. So that if the geologists can determine the number and position of coal horizons, and then further the character, general thickness, regularity and variability of each bed, it may be possible to predict roughly the coal contents of a piece of land without ever touching foot on it.

STATE GEOLOGICAL SURVEY AND THE FARMING INTERESTS.*

In the marvelous development that is taking place in the South today the keynote has been cooperation. We all recognize that with few exceptions one man alone cannot advance very far. It is only as he takes advantage of all of the experiences and experiments, not only of his immediate neighbors, but of those having similar problems over the whole world, that he makes the most rapid advance. He may get this in part from such meetings as this, from the agricultural journals, or from the talks and publications of the State and Government agencies for aiding the farming interests. Among these agencies in this State may be counted the State Geological Survey.

This Survey has not, as yet, been in existence long enough to "point with pride" to a long line of services, and the benefits which should be derived from such services. On the contrary, in the seven months of its existence, it has been able only to inaugurate work in various lines, and so today instead of telling you what the Survey has done for the farming interests, I must content myself with mapping out its program, telling you incidentally what has been started.

One-half of the farmers' problems have to do with the ground and its contents, and the other half have to do with the plants and animals he raises. The Geological Survey has to deal with the ground half of his problems—the mapping and study of soils, the drainage of marsh lands and river bottoms, the supply of water, the study of hillside wash, its prevention and amelioration, the location, extent and adaptability of road materials, and the methods of road building best adapted to any locality, belong in the province of its work. In addition the study of the forests has been added to the duties of the Survey.

The Survey has now been running seven months. During that time it has given more attention two or three times over to the drainage of the overflowed river bottoms of Tennessee than to any other one problem. It was felt that this work was of definite and tangible value, and that there was no guess work about its repaying every dollar spent on it several times over in actual dollars and cents. The actual results accomplished this season have recently been published in the papers. It has been estimated that there are 1,000,000 acres of the State's richest farm lands in the bottoms of the little rivers of West Tennessee alone, now practically valueless, that can be reclaimed at from $5.00 to $20.00 an acre. This does not include the Mississippi River bottoms, or the river bottoms of Middle and East Tennessee, and

---

*Address before State Farmers' Institute, Nashville.

Stewart County alone has been estimated to contain 50,000 acres of bottom lands.

A beginning has been made toward detailed soil surveys. It had been expected that much more would be done, especially as the result of a cooperative agreement with the U. S. Bureau of Soils. This Survey was established too late to enter into the regular program of that bureau. However, an agreement was made for a small amount of work to be done after the completion of some of the northern work, but unfortunately the bureau has found it impossible to carry out its part of the agreement. By taking up the matter in due season next year, it is hoped that much work may be accomplished.

In the soil work, which the Survey proposes to do, it has been planned that all of the work done except preliminary studies shall be in as great detail as any of the geologic work, and the U. S. Bureau of Soils in entering into a cooperative agreement to assist in such soil surveys has agreed that such work as it may do in this State in the future will be in such detail. To do detailed geologic work or soil work involves the possession of an accurate detailed base map. Such a map to be of value should be on such a scale and have such a degree of accuracy that it is possible to represent boundaries of any type of rock or soil within at least one to two hundred feet. On most of the old maps it was often impossible to show boundaries closer than a fourth to a half mile, and you could not tell whether the boundary included your farm or not. There are regions in which identical conditions spread over whole counties, but in this State, as a rule, the series of rocks differ in character, and each one is exposed in outcrop, and therefore responsible for a corresponding soil over usually rather narrow belts. Thus of two limestones similar in appearance, one may be highly phosphatic and the other not, resulting in a narrow strip of soil with a high phosphate content, while just beyond it is another strip of soil entirely lacking in phosphate. To simply group such rocks as all the same as has sometimes been done in the past, because they have somewhat the same appearance and physical structure, is of little value. So that in our detailed soil maps, as well as in our geological maps, we are planning to confine our work to those regions where such accurate base maps exist. Where such maps do not exist, it will be the purpose of the Survey to secure them as rapidly as possible. Such maps are being made by the U. S. Geological Survey, but they can cover only a small territory in any one year, unless the State will cooperate, and the State Survey is already cooperating as far as its funds will allow.

Prof. Glenn, of Vanderbilt University, who has already given several years' study to the water resources of the State, is continuing that study under the Survey, and has a bulletin on these resources in preparation. In this work the cooperation of the Water Resources Branch of the U. S. Geological Survey has been secured by which the Survey's report will have the benefit of all of their records and data.

The study of the water resources will include a study of the sources of water, for farm and other use, not only as at present being obtained, with its quality, etc., but also whether other sources of supply lie deeper, whether they would be artesian in character or not, whether hard or soft, likely to be contaminated or not, the possibilities of water storage, water power, mineral springs, etc.

Definite studies on road materials have been started, and a report on road building in this State is now in preparation. It is intended that that bulletin shall emphasize especially the possibilities of the several regions of the State securing good roads by the use of materials close at hand, or of methods to which the natural soils or lay of the land are naturally adapted, such as the building of sand-clay roads, etc.

Studies of hillside wash and its prevention and the reclamation of lands already injured will form a subject of work in the near future. Prof. Glenn has already given a large amount of attention to this subject and to the subject of the filling of the river channels, under the auspices of the U. S. Forest Service, and is therefore well prepared to take up that subject after the completion of his present study of water resources. Preliminary studies of the forests of the State are now being made in cooperation with the U. S. Forest Service, and it is hoped to follow that up by a more detailed study, which may in the future solve the problem of maintaining our lumber industry. The report on these studies will be made public the coming winter.

One of these studies is being made of the forest conditions all over the State to secure data which will be of value in formulating and carrying out a definite State program. The other study, just started this week, has to do with second growth timber in the Appalachian region, especially determining its rate of growth under the varying conditions, the kinds of timber that grow under these conditions, and other related facts. With these facts it should be possible to so plan methods of forestry that the yearly growth will just balance the yearly cut, and the forest becomes a continuing supply.

In addition to the subjects which I have mentioned and which are of interest to you primarily in connection with your work as farmers, there is another side of the matter, which has a very large interest for all landowners and without any question the farmers are the largest landowners in the State. Thus the Survey is making studies of the coal, clay, iron, oil and gas, building stone and a hundred other mining and geological materials. And it will be noticed that all of these materials exist in the ground. Experience has shown that a large part of the Survey's work is in answering inquiries from the owners of land as to the value of materials which they find on their land, or as to the possibility of certain minerals being on their land or under it, the determination of specimens, etc. Of even more importance, the actual mapping being done in the field gives to the farmer an idea of what may be of value from a mineral standpoint, on or under his land. For these reasons similar surveys in other States have shown themselves to have as much value to the farmers as landowners as to the mining and quarrying interests.

Now, I said in the beginning that the advance of the South has been due to cooperation, the same as the advance elsewhere. But what has the Geological Survey to do with cooperation? Simply this: The Geological Survey and all of the other State and Government scientific departments and bureaus are simply clearing houses of information and experiences. Cooperation begins when you and your next door neighbor swap notes over the garden fence. If your neighbor is a wideawake gardener and of an experimental turn of mind, you could doubtless get many pointers from such note swapping, and if you could swap notes with all of the wideawake gardeners of an experimental turn of mind, who have the same problems as you, you could doubtless go a long ways towards solving your problems. The Geological Survey, the Department of Agriculture, the Forest Service, the Bureau of Soils, and all the other scientific bureaus, both State and National, are primarily organizations for the purpose of bringing together the experience of men in dealing with their thousand and one problems, drawing general conclusions from the most successful experiences and publishing these for the benefit of all that may be interested.

But these scientific bureaus go further than that. When none of the experiences of which they learn appear to have been entirely successful, they try experiments on their own hook, on the experimental farm, on experimental roads and forests, in the laboratory, etc., and then publish the results of these experiments. Sometimes these studies are of such nature or are so costly that it would be almost out of the question for private individuals to carry them on; such as the study of the transportation of citrus fruit recently carried on by the U. S.

Department of Agriculture, which probably cost $20,000 to $40,000. But it is said that the results of that work are saving the orange growers of California alone $1,000,000 a year, and numberless similar examples might be cited.

In its studies directly affecting the farming interest, the State Geological Survey has in nearly all cases cooperated with the Department of Agriculture. In this first season of work we have cooperated with the Drainage Investigations Division, the Bureau of Soils, the Division of Public Roads and the Forest Service; but notice that in each case it has been with the Federal Department of Agriculture, not with the State department. Now, this has been so not because we do not want to cooperate with the State Department of Agriculture, or they with us, but simply because they do not have the money with which to cooperate. Therefore, our cooperation with that department has been confined to conferences and the giving of advice and counsel, all of which has been most freely given. If this State did as well by its Department of Agriculture as the United States does by its department, the State Department would be given $200,000 to $300,000 a year or more, depending on what basis you use in comparing this State with the United States. You realize what Col. Thompson has done in this State, practically without funds. Can you imagine what he could have done if he had had funds? We talk about investing in gold mines. I venture to say that very few gold mines in the world's history has ever returned as much on the investment as has been received from the appropriations given to the U. S. Department of Agriculture, and I do not see any reason why your State Department of Agriculture should not return equal dividends if as liberally supported.

APPENDIX D—EXHIBITS.

Exhibit at Appalachian Exposition, Knoxville, September 12 to October 12, 1910.—In the plans for an exposition of the resources of the Appalachian region, held at Knoxville, Tennessee, from September 12 to October 12, a cooperative agreement was entered into between the State Geological Survey and Appalachian Exposition Company, to cooperate in preparing an exhibit of the State's resources. Dr. Chas. H. Gordon, Professor of Geology at the University of Tennessee, and Associate Geologist of the Survey, was placed in charge of the proposed exhibit. The exposition company furnished a one-story frame building 64 x 82 feet in size, situated upon the crest of a knob overlooking the exposition grounds. This building was shared by the mineral exhibit and the forestry exhibit. The main part of the coal display consisted of a building constructed entirely of blocks of coal, standing in front of and below the main buliding. The coal building contained two rooms and intermediate passage way, and it is needless to say proved to be one of the most striking features of the exposition.

In the main building the most attractive feature was the marble exhibit, consisting of seven marble pedestals, four feet by four feet or two feet by four feet, and about three feet high, in part supporting a timber pergola. On the top of the corner pedestals were placed large masses of ores and between them were show cases of minerals, fossils, etc. The exhibit contained large displays of the iron ores of East Tennessee, zinc, copper, phosphate, slate, coal and other minerals. A large amount of material was loaned by the University of Tennessee, including minerals, fossils, relief maps, photographs, etc. It is safe to say that a large majority of the people who visited the exposition examined the mineral exhibit. In addition to the display from Tennessee, a small amount of material was shown from other States. The general appearance and character of the exhibit is shown in the photographs of the frontispiece.

As the exposition company has leased the present grounds for ten years, and plan to make the exposition a yearly one, for at least that length of time, it was felt it would be unwise to attempt to transfer the material to Nashville and to send it back again each year, as much of the material is very heavy and the glass cases would be very liable to breakage; accordingly only a few typical specimens were selected from certain of the exhibits and sent to Nashville to combine with the collections being formed there. These included notably two pairs of slabs of marble, a number of blocks of iron ore from East Tennessee, a suite of copper ores and the minerals accompanying the copper, and a few miscellaneous specimens. Mr. Gordon has forwarded the following list of those who donated material for the exposition:

Adams, John N., Del Rio, Tenn.	Iron ore
Buffet, A. G., Knoxville, Tenn.	Zinc ore
Cranberry Furnace Co., Johnson City, Tenn.	Iron ore and furnace products
Davis, T. L., Sharp's Chapel, Tenn.	Zinc ore
Donelly & Wills, Mountain City, Tenn.	Iron ore
Ducktown Copper, Sulphur Iron Co., Isbella, Tenn.	Copper ores, associated minerals and smelter products
Evans Marble Co., Knoxville, Tenn.	Tennessee marble
Gray Eagle Marble Co., Knoxville, Tenn.	Tennessee marble

VIEW OF NORTH END OF EXHIBIT.

PART OF EXHIBIT OF CLAY AND CLAY PRODUCTS OF WEST TENNESSEE.

STATE GEOLOGIC EXHIBIT AT NASHVILLE.

Killebrew, Geo. W., Mt. Pleasant, Tenn.	Lime phosphate
Knox Marble & Railway Co., Knoxville, Tenn.	Tennessee marble
N. C. Talc & Mining Co., Hewitt, N. C.	Marble, talc, etc.
Peck, T. F., Etowah, Tenn.	Gold ore from Coker Creek, Tenn.
Rockwood Furnace Co., Rockwood, Tenn.	Iron ore, coal, coke and pig iron
Ross & Republic Marble Co., Knoxville, Tenn.	Tennessee marble
Royal Marble Co., Knoxville, Tenn.	Tennessee marble
Southern Coal Operators' Assn., Knoxville, Tenn.	Coal building
Southern Gypsum Co., North Holston, Va.	Gypsum and its products
Tellico Co., Tellico Plains, Tenn.	Brown iron ore and slate
Tennessee Copper Co., Copper Hill, Tenn.	Copper ore
Victoria Marble Co., Knoxville, Tenn.	Tennessee marble
Zechini Coal Co., Newcomb, Tenn.	Cannel and bituminous coal
Blount County	Slate
Hancock County	Iron and zinc ores, etc.
Union County	Iron ore, zinc ore, etc.

Loan contributions—

Barber, M. D., Knoxville, Tenn.	Fossils
North Carolina Economic and Geological Survey	Minerals, etc.
University of Tennessee	Minerals, maps and pictures

State Geological Exhibit at Nashville.—Soon after the starting of the Survey an attempt was made to gather material looking to the starting of a permanent geological exhibit. This material consisted principally of specimens obtained by members of the Survey in the several fields being examined by them. After the Knoxville exposition some of the material from that display was shipped to Nashville and added to that already gotten together. At this writing about one thousand specimens have been collected toward such an exhibit. Late in the fall a room on the third floor in the Capitol Annex was prepared, and exhibition cases and shelving was obtained and the material prepared and the exhibit opened to the public. At present the exhibit consists first of a large collection of clays from West Tennessee and of the various products made from these clays, including many examples of fine pottery, encaustic tile, electric insulators and other high grade wares made from the clays of Tennessee, but by plants located outside of the State. There is a fair exhibit of the iron ores of East Tennessee, a suite of specimens illustrating the copper ores of Polk County; zinc, lead, manganese and other ores; a small display of marbles; a display of the various types of phosphate rock and the prepared products; and a display of the minerals, fossils and rocks of the State. Outside of the clays of West Tennessee, which are fairly complete, the other materials form only the beginning of what it is hoped may ultimately be shown.

In addition to the material collected by the State Geologist or members of the Survey, much material has been donated to the collections; some of this is material that has been sent in for identification. Only the larger specimens, as a rule, have been put on exhibition. Among these the following donations may be noted:

Akron Smoking Pipe Co., Magadore, O	Electric insulators
Bailey, Jas., Coal Creek, Tenn	Silica rock and ochre
Baker, —., Nashville, Tenn	Decayed chert
Bellamy, —., Sweetwater, Tenn	Manganese
Blevins, John, Blount County	Manganese
Bransford, T. L. & Sons, Union City, Tenn	Brick and Columbia loess
Brewer, Sterling C., Thomasville, Tenn	Wad
Brittain, J. F., Blount County	Brown hematite
Brockman Pottery Co., The, Cincinnati, O	Encaustic tile
Brunt, G. F., Porcelain Co., E. Liverpool, O	Insulators
Buffalo Pottery Co., Buffalo, N. Y	Plate
Cambridge Tile Mfg. Co., Covington, Ky	Encaustic tile
Cartwright, J. B., Goodlettsville, Tenn	Hematite iron ore
Cartwright Bros., E. Liverpool, O	Plate
Cooke Pottery, Kittanning, Pa	Plates, cup and saucer
Costen, Moore & Co., McKenzie, Tenn	Pressed brick
Creswell, J. M., Milan, Tenn	Soft mud brick
Davenport Brick Co., LaGrange, Tenn	Brick
Findlay Electric Porcelain Co., Findlay, O	Tube and insulator
Fulcher Brick Co., Nashville, Tenn	Brick
Gem Clay Forming Co., Sebring, O	Pitcher and gas tips
Gilmore Brick Co., Gilmore, Tenn	Fire and pressed brick
Grand Junction Pottery Co., Grand Junction, Tenn	Pottery
Green, —., Nolensville, Tenn	Lead ore
Hall China Co., E. Liverpool, O	Plates, cups, saucers and dish
Harley Pottery Co., Nashville, Tenn	Seger cones, burnt
Hartford Faience Co., Hartford, Conn	Electric insulators
Hawks, Wm., Nashville, Tenn	Kaolin and white granite ware
Keinworth Tile Co., Newell, W. Va	Mosaic tiles and plates
Kent, W. W., Enville, Tenn	Lead ore
Locke Insulator Mfg. Co., Victor, N. Y	High tension insulators
Long & Co., Jackson, Tenn	Brick
McKnight Bros., Humboldt, Tenn	Brick
Mayer Pottery Co., Beaver Fall, Pa	Plate, cups, saucers, pitcher and dish
Merrill, G. P., Washington, D. C	Marble
Milan Brick Co., Milan, Tenn	Brick
Mosaic Tile Co., Zanesville, O	Encaustic tile
Murray, J. J., Lewisburg, Tenn	Lime wavelette
Nonconnah Pottery, Capleville, Tenn	Pitcher, platter, cup, jardiniere, box
Ohio Electric Porcelain Co., E. Liverpool, O	Insulators
Ohio Porcelain Co., E. Liverpool, O	Bell
Oliver Springs Coal & Clay Co., Oliver Springs, Tenn	Brick and shale
Owen China Co., Minerva, O	Bowl, coffee pot, cup and saucer, etc.

Phelus, J. L., Lobelville, Tenn	Decayed chert
Pinson Pottery Co., Pinson, Tenn	Jugs, jars, etc.
Pittsburg High Voltage Co., Pittsburg, Pa	Insulators
Powell, J. B., Nashville, Tenn	Limonite
Quarles, R. T., Nashville, Tenn	Limonite
Reynolds White Sand Co., Bristol, Tenn	Glass sand
Reynolds, H. E., Nashville, Tenn	Lead ores
Roseville Pottery Co., Roseville, O	Jardinieres, pitchers, vase, etc.
Sanitary Pottery Co., Tiffin, O	Urn
Schmidt, M. G., Nashville, Tenn	Chattanooga shale
Sebring Pottery Co., Sebring, O	Platter
Sharer, Mrs. Ollie, Greenbrier, Tenn	Bog ore
Shenango Pottery Co., New Castle, Pa	Plate
Southern Tile & Brick Co., Gilmore, Tenn	Brick
Sparks Pottery Co., McKenzie, Tenn	Jugs, jars, jardiniers and brick
Taylor, Lytton, Nashville, Tenn	Fluorspar, zinc blend, hematite, iron, lead ore
Thompson, C. C., Pottery Co., E. Liverpool, O	Plate
Thompson, John, Nashville, Tenn	Bog iron ore, limestone (Newsom Sta.) and limestone (Goodlettsville)
Thomas, The R. & Sons Co., East Liverpool, O	High tension electric insulators
Toops, J. F., Dckson, Tenn	Clay
Unaka Mining & Development Co., Coker Creek, Tenn	Gold ore
Universal Sanitary Mfg. Co., New Castle, Pa	Sanitary ware
U. S. Electric Porcelain Co., New Cumberland, W. Va	Tubes, insulators, etc
Vodrey Pottery, E. Liverpool, O	Plate
Wheeling Tile Co., Wheeling, W. Va	Mosaic tiles and plate
Winter, C. C., Lebanon, Tenn	Calcite crystal

The donation of other similar material is solicited.

It is hoped later on to be able to prepare small collections for distribution to such of the secondary schools of the State as are giving courses of study along the line of the Survey's work. While some of the material already collected will be available for that purpose, it will be some time yet before enough such material has been gathered to make it worth while to begin such distribution.

PLATE 1.

Part of Exhibit of Clays and Clay Wares in Geological Exhibit, Nashville.

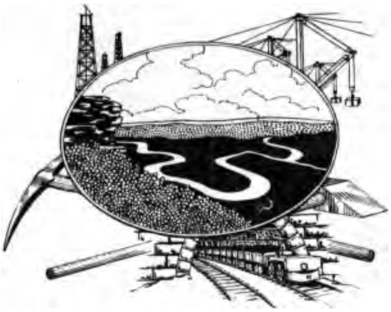
STATE OF TENNESSEE
STATE GEOLOGICAL SURVEY
GEORGE H. ASHLEY, STATE GEOLOGIST

BULLETIN 5

Clay Deposits of West Tennessee

BY

WILBUR ARMISTEAD NELSON



NASHVILLE
FOLK-KEELIN PRINTING COMPANY
1911

State Geological Commission.

GOVERNOR BEN W. HOOPER, CHAIRMAN.

DR. BROWN AYRES, SECRETARY,
President University of Tennessee.

COL. JOHN THOMPSON,
Commissioner of Agriculture.

PROF. J. H. KIRKLAND,
Chancellor Vanderbilt University.

PROF. WM. B. HALL,
Vice Chancellor University of the South.

R. A. SHIFLETT,
Chief Mine Inspector.

GEO. H. ASHLEY,
State Geologist.

CONTENTS

Page

- Introduction 1
- Geography of Area 2
  - Location 2
    - Topography 2
    - General character 2
    - Tennessee-Mississippi Divide 2
    - Residual ridge 3
    - Hills of erosion 3
    - The flatwoods 4
    - Alluvial region 4
  - Origin of Topography 4
    - Origin of "flatwoods" 5
    - Origin of "hills of erosion" 5
    - Disturbances 5
  - General development 6
    - Railway facilities 6
    - Character of roads 7
    - Cities and towns 7
- Geology of area—Stratigraphy 8
    - General statement 8
  - Formations described and their description 8
  - Paleozoic rocks 8
  - Cretaceous system 9
    - Eutaw sand 9
      - Extent 9
      - Lithological character 9
      - Section 9
      - Thickness and dip 10
    - Selma clay 10
      - Extent 10
      - Lithological character 11
      - Section 11
      - Thickness 11
    - Ripley sands 11
      - Extent 11
      - Lithological character 11
      - Section 12
      - Thickness and dip 13
  - Tertiary System 13
    - Eocene Series 13
      - Porter's Creek formation 13
        - Extent 13

Page

Tertiary System—Con.

- Lithological character 13
- Section 13
- Thickness and dip 14
- LaGrange formation 14
  - Extent 14
  - Lithological character 14
  - Section 15
  - Fossils 16
  - Thickness 16
- Pliocene Series 16
  - Lafayette formation 16
    - Extent 16
    - Lithological character 16
    - Section 17
    - Thickness 17
- Quaternary System 17
  - Pleistocene Series 17
    - Columbia formation 17
      - Extent 17
      - Lithological character 17
        - Sands 17
        - Loess 17
        - Loam 18
  - Recent deposits 18
    - Alluvim 18
      - Extent 18
- Clays of the Area 18
  - Definition of clays of area 18
    - Kaolin 18
    - Ball clay 19
    - Sagger clay 19
    - Wad clay 19
    - Potters clay 19
    - Common brick 20
      - Colors 20
    - Drainage tile clay 20
    - Fire brick clay 21
  - Mixtures of clays used in certain manufactured wares 22
    - Electrical ware 22

Page
Clays of the Area—Con.
- Porcelain and china 22
- White ware 22
- Sanitary ware 22
- Stone ware 22
- Character of deposits 22
  - Embayment clays 22
  - Deposits in fresh water ... 23
  - Deposits in brackish water. 24
  - Deposits under marine conditions 24
  - Glacial clays 24
  - Lacrustine clays 25
  - Floodplain and terrace clays 25
- Stratigraphic position of deposits 25
  - Eutaw sands 25
  - Selma clays 25
  - Ripley fomation 25
  - Porter's Creek formation.. 26
  - LaGrange formation 26
  - Lafayette formation 27
  - Columbia formation 27
- General distribution of deposits 27
  - Ripley formation 27
  - LaGrange formation 27
  - Lafayette formation 28
  - Columbia formation 28
  - Resume 28
- Tests on shrinkage, fusibility and colors of West Tennessee clays 28
  - Methods employed in making the tests 28
  - Tests 29
- Mining, preparation and manufacture 30
  - Mining 30
    - Brick clay 30
    - Potters clay 30
  - Grinding 31
    - Dry pan 31
  - Conveyors 31
  - Screens 31
  - Tempering 32
    - Soaking pits 32
    - Wet pan 32
    - Pug mill 32
    - Chaser mills 33

Page
Clays of the Area—Con.
- Molding 33
  - Soft mud 33
  - Stiff mud 34
  - Dry press 34
  - Repress machine 35
  - Turning 35
  - Repressing 35
- Drying 35
- Burning 35
  - Difference in cost 35
  - Scove kilns 36
  - Dutch kilns 36
  - Downdraft kilns 37
  - Continuous kilns 37
- Labor 37
- Brick output for 1910 38
- Clay output for 1909 39
- Selling price of brick and clay 39
- Selling price and output of stoneware for 1909 39

Clay resources by counties 40
- Benton County 40
- Carroll County 40
  - Topography 40
  - Railroads and towns 40
  - Geology 41
  - Clay deposits 41
    - Hico 41
    - Hollow Rock 44
    - Huntingdon 47
    - McKenzie 49
    - Trezevant 52
- Chester County 56
  - Topography 56
  - Railroads and towns 56
  - Geology 56
  - Clay 57
- Crockett County 57
  - Topography 57
  - Railroads and towns 57
  - Geology 57
  - Clays 57
- Decatur County 57
  - Topography 57
  - Railroads and towns 58
  - Geology 58
  - Clays 58
- Dyer County 58

Page
Clay resources by counties—Con.
    Topography 58
    Railroads and towns 58
    Geology 59
    Clays 59
        Dyersburg 59
  Fayette County 60
    Topography 60
    Railroads and towns 60
    Geology 61
    Clay deposits 61
        LaGrange 61
        Follis pits 62
        Moscow 63
        Somerville 64
  Gibson County 64
    Topography 64
    Railways and towns 64
    Geology 65
    Clay deposits 66
        Humboldt 66
        Milan 69
        Trenton 72
  Hardeman County 72
    Topography 72
    Railroads and towns 73
    Geology 74
    Clay deposits 74
        Bolivar 74
        Bolivar asylum 74
        Grand Junction 76
        Hickory Valley 76
        Middleburg 77
        Middleton 77
        Rogers Spring 77
        Toone 77
        Whiteville 79
  Hardin County 79
    Topography 79
    Railroads and towns 79
    Geology 80
    Clays 80
  Haywood County 80
    Topography 80
    Railroads and towns 80
    Geology 80
    Clay 80
  Henderson County 81
    Topography 81
    Railroads and towns 81

Page
Clay resonrces by counties—Con.
    Geology 81
    Clays 81
        Lexington 81
        Scott's Hill 82
  Henry County 82
    Topography 82
    Railroads and towns 83
    Geology 83
    Clays 83
        Cottage Grove 83
        Henry 84
        India 89
        New Boston 91
        Paris 91
        Puryear 92
        Whitlock 93
        Routon 97
        Vale 97
  Lake County 97
    Topography 97
    Railroads and towns 97
    Geology 97
    Clay 98
  Lauderdale County 98
    Topography 98
    Railroads and towns 98
    Geology 98
    Clay 98
        Ripley 98
  Madison County 99
    Topography 99
    Railroads and towns 99
    Geology 99
    Clay 99
        Gilmore 100
        Jackson 101
        Malesus 103
        Medon 103
        Pinson 104
  McNairy County 106
    Topography 106
    Railroads and towns 106
    Geology 106
    Clays 106
        Selmer 107
  Obion County 107
    Topography 107
    Railroads and towns 107
    Geology 107

Page
Clay resources by counties—Con.
  Clay 108
    Obion 108
    Rives 108
    Union City 108
 Shelby County 109
  Topography 109
  Geology 109
  Clays 109
    Capleville 109
    Memphis 110
 Tipton County 111

Page
Clay resources by counties—Con.
  Topography 111
  Railroads and towns 111
  Geology 111
  Clay 111
    Covington 111
 Weakley County 112
  Topography 112
  Railroads and towns 112
  Geology 112
  Clay 112
    Martin 112

ILLUSTRATIONS

Plate 1. Frontispiece. Part of exhibit of clays and clay wares in Geological Exhibit.
Plate 2. Typical view of upland plateau of West Tennessee ....Between 2-3
Plate 3. Key Map of West Tennessee .... " 8-9
Plate 4. Typical exposures of Lafayette and LaGrange formations .... " 14-15
Plate 5. Old and new methods of burning brick .... " 36-37
Plate 6. Brick plants of West Tennessee .... " 38-39
Plate 7. Map of clay outcrops at McKenzie 42
Plate 8. Map of clay outcrops at Trezevant 53
Plate 9. Map of clay outcrops at Milan 68
Plate 10: Map of clay outcrops at Lexington 78
Plate 11. Map of part of Henry County, showing clay pits ....Between 82-83
Plate 12. Clay deposits in LaGrange formations near Henry ... " 84-85
Plate 13. Clay deposits in Ripley formation, near India .... " 88-89
Plate 14. Clay deposits in LaGrange formation, west of Whitlock .... " 95-96
Plate 15. Jackson, Madison County, and vicinity .... " 102-103

Figure 1. Road exposure, showing formations near Scott's Hill, Tenn 10
Figure 2. Road exposure of Porter's Creek clay 13
Figure 3. Clay outcrops and developments near Hollow Rock 45
Figure 4. Cross section of road, showing surface formation south of Huntingdon 48
Figure 5. Cross section of road, showing surface formations on Baxter Hill, 5 miles east of Trezevant 55
Figure 6. Exposure, showing clay lens in Southern railroad, 2 miles east of Moscow, Tenn. 63
Figure 7. Humboldt and vicinity 65
Figure 8. Cross section of road, showing surface formations, 1 mile west of Milan, on Lower Trenton road 70
Figure 9. Hardeman County, showing geological formations 71
Figure 10. Bolivar, Hardeman County, and vicinity 73
Figure 11. Grand Junction, Hardeman County; LaGrange, Fayette County, and surrountding territory 75

INTRODUCTION.

This report deals with the clays of West Tennessee—both those at present worked, and those giving promise on the outcrop, when not too far from the railroads. These clays have a peculiar interest in that West Tennessee is at present furnishing probably the finest ball clay obtained in the United States, as well as sagger, wad and other fine clays, not to mention clays for terra cotta, tile, brick and fire clays. These ball clays have also a large future interest in that the exportation of ball clay from England, the principal source of supply in the past, may be stopped by law in the near future. The value of the report is enhanced further by the fact that, at present, little information on the clays of West Tennessee is available. In his "Clays, Occurrences, Properties and Uses," Reis says (.475) "Probably less is known regarding the clays of Tennessee than those of any other eastern State," the principal papers being two articles of a few pages each by Eckel (1), and Crider (2).

This report is only preliminary in character, dealing primarily with the deposits as found in the field, their location, extent, thickness, character, overburden, geological position, etc. A few of the clays not now worked were burned in a Seger furnace, but a detailed physical and chemical study of the clays will be reported upon later in a special report.

The ball clays found in this section are as good as any in the United States, and have already a large and permanent market in the North where they are eagerly sought after; the demand always being larger than the output. They are at present mined only in Henry County.

Good grades of potters clay are found in many of the counties, and are shipped as well as used locally. At present the local use is small. Fire and brick clays are found in practically all of the counties, but at present fire brick are only manufactured at one locality, Gilmore, Madison County, while the ordinary brick are made in all the towns of any importance. Practically the whole surface of West Tennessee could be utilized in the making of common brick.

In preparing this preliminary report on the western clays, a part of the late fall of 1910 (November and December) was spent in a hurried and brief survey of the field. No detailed work was done and only places were visited where plants were in operation, or where information had been given in regard to "blossoms." No drilling or prospecting work was done, as the time was too short. In several instances information was procured by correspondence from owners of mines and well drillers.

---

(1) Eckel, U. S. Geological Survey, Bull., 213, p. 382, 1903.

(2) Crider, U. S. Geological Survey, Bull., 285, p. 417, 1906.

It is the intention of the Survey later on to publish bulletins of the clays of Middle and East Tennessee, making, when finished, a complete preliminary clay survey of the State.

GEOGRAPHY OF AREA.

LOCATION.

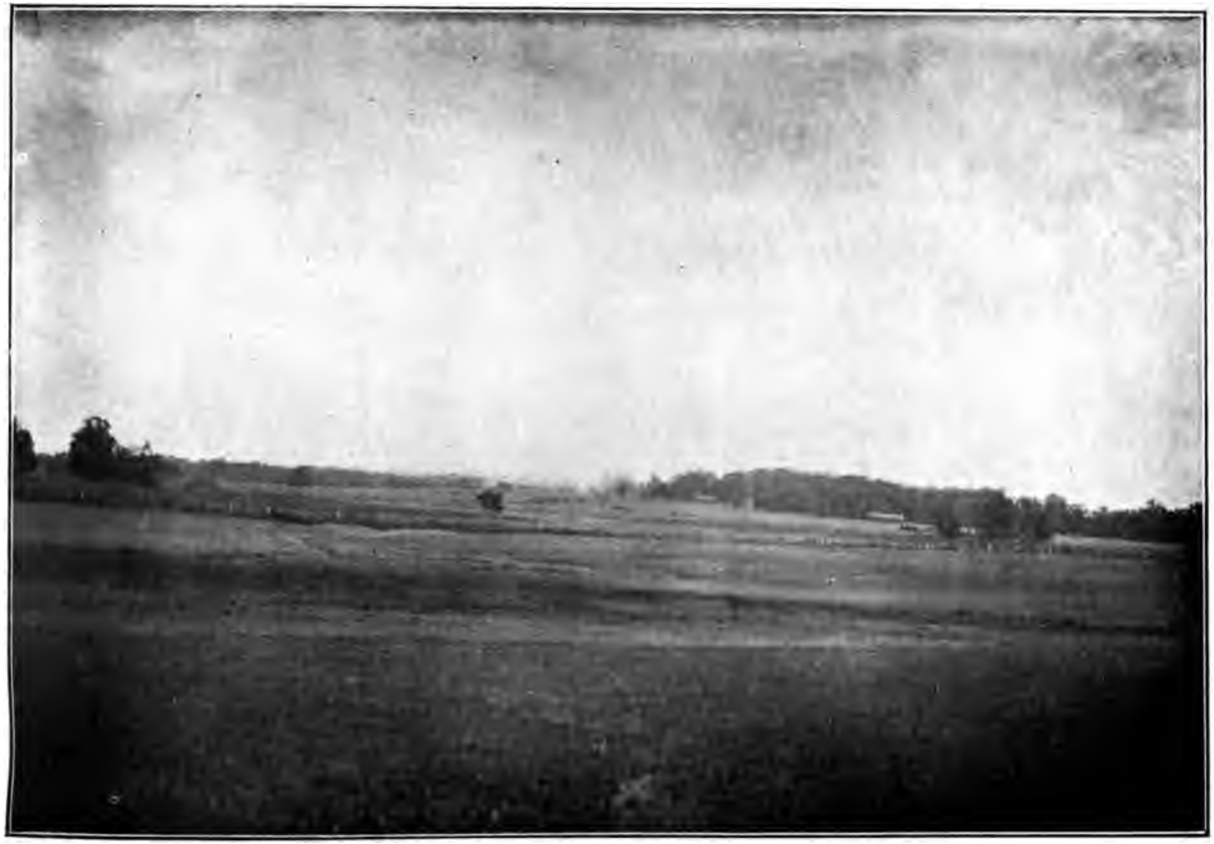
This report describes that part of Tennessee which lies between the Tennessee and Mississippi rivers. A large share of the time was spent in a belt extending through Henry, Carroll, Gibson, northwestern Henderson, eastern Madison and Hardeman counties, as that is the belt known to contain the clays of highest grade. The rest of the district was covered only in a very reconnoissance manner.

TOPOGRAPHY.

General character—The surface of the part of Tennessee under discussion varies from very broad flood plains along the main streams and their principal tributaries to a gently rolling and hilly surface along the valley sides and in the areas between the streams. Sometimes the divides are level and plateau like, bordered by steep and irregular slopes on the edge of the valleys, which vary from a few yards to several miles in width. At present most of them are subject to overflow at all times of the year. The larger valleys have also an older flood plain, which is known as the "second bottoms," and is separated from the present flood plain by a well defined escarpment of from two to fifteen feet or more

Tennessee-Mississippi divide—This divide, the principal one in West Tennessee, separates that portion of the State into two distinct drainage areas, of very unequal size. It runs northward parallel to the Tennessee River, and at a distance from it of from ten to twenty-five miles, having a height which averages 450 to 500 feet, though in places it reaches an altitude of 600 feet. This ridge being near the Tennessee River, makes the Tennessee drainage slope short and steep, with small streams flowing directly into the Tennessee River; though in the northern part, the main stream, the Big Sandy, attains considerable length by flowing parallel to the Tennessee River, before emptying into it. West of the divide the general slope of the surface is long and gentle.

PLATE 2.



Typical View of Upland Plateau of West Tennessee. ½ Mile Northwest of Hico.

The main streams, such as Wolf, Hatchie, Forked Deer and Obion, flow directly into the Mississippi. These streams do not, as a rule, furnish opportunities for water power development, as the fall per mile is very small. Instead, most of them are bordered on both sides by cypress swamps, though under a recent law active measures are being started to reclaim these rich bottom lands.

The slope from the Tennessee-Mississippi divide eastward is gentle, but there is an abrupt drop along the Tennessee River of one hundred to two hundred and fifty feet to the river flood plain. Westward the slope is in general to the west, but locally the slopes are to the main drainage streams. (See Plate 2.) The general westward slope is broken by a ridge that extends northward from the Mississippi State line through McNairy County, and by a number of high hills of a general elevation of 550 feet, which extend up from Grand Junction, through Jackson, Milan and Paris, along the eastern outcrop of the LaGrange sands, and its interbedded clay lenses. These two features, which may be distinguished for want of better names as the "residual ridge" and hills of arosion" are described in succeeding paragraphs.

Residual ridge—This ridge is about one half mile wide and between one hundred and two hundred feet high. It extends from Mississippi, northward into the southwestern part of McNairy County, where it gradually dies out. It is caused by the presence of a large amount of concretionary ironstone, with which its sands have been cemented by percolating waters. This has protected the underlying Ripley sands from erosion, while the areas on either side have worn away. A good exposure of this is found in the "big cut" just west of Cypress Station, where the Southern Railway crosses this ridge.

East of this ridge, in the southern part of the State, the Eutaw sands and Selma clays, which form the eastern outcrops of the embayment deposits in southern Tennessee, are cut into steep hills. This is caused by their situation on the short steep drainage slope of the Tennessee River, and also on account of their composition, since they are easily eroded.

Hills of erosion—In the eastern part of the LaGrange formation an unusually hilly belt extends across the State from Hardeman to Henry counties. These are developed best around the town of LaGrange in Hardeman County, and at Cottage Grove in the northwest part of Henry County. The materials are easily eroded, being soft sands with lenses of clay interspersed. In an abandoned field, gullies will soon form, and in several years make the land worthless. The gullies average 20 to 30 feet, but under favorable conditions they will be over

120 feet deep. It is by the aid of these gullies that most of the prospecting for clay is done in this region, and all of the best pits occur in this belt of hills.

The flatwoods—This name is given in Mississippi to that portion of the country which is underlaid by the Porter's Creek formation, as it is of more than average flatness. In Tennessee, only in the northern portion of the State near the Kentucky border line, do such conditions prevail, the surface over the Porter's Creek formation in the rest of the State having no distinctive features.

Alluvial region—West of the line of bluffs which terminates the uplands of West Tennessee, there are alluvial bottom lands, along the Mississippi River, which are part of the flood plains of that river. Part of them are low ridges which are high enough not to be submerged under high water. So we have a surface which is flat, but broken by low ridges a few feet high or by old stream channels, "cut offs," partly filled with water. On the river bank in many places, the land is somewhat higher, forming bluffs about fifty feet high, as at Memphis, which is generally cultivated; while back from the river to where the uplands commence, the land is swampy and uncleared. The elevation of this land is from about 215 feet at the Tennessee-Mississippi State line to about 300 feet at the Tennessee-Kentucky line.

ORIGIN OF TOPOGRAPHY.

All the surface inequalities of West Tennessee are due to erosion with the exception of a small area around Reelfoot Lake, in the northwest corner of the State, where there were disturbances in 1811 and 1812, during the New Madrid earthquake. The surface was originally a plain, formed by deposition, under marine conditions, when West Tennessee was an embayment of the Gulf. This gulf bottom was subsequently lifted up and since then completely dissected by stream erosion into its present topography. There were in this general uplift several minor periods of uplift and depression; probably with a subsequent slight warping or tilting.

The erosion has been slight on account of the low elevation of this region. So the streams soon cut as deep as they could, then began to broaden their valleys, and forming their flood plains of several miles extent; then came a slight depression, which was very brief, during which a light deposit of loess was laid down; then came the uplift, and the streams commenced cutting away their flood plains, and forming new ones from five to fifteen feet lower, which have attained a width of not more than a mile and a half. All of this has occurred in a comparatively short time, as the formations are composed chiefly of soft sands and clays.

Origin of flatwoods—The origin of the "residual ridge" has already been given, but that of the "flatwoods" has not. The "flatwoods" are caused by the impenetrability of the Porter's Creek clay to water, thus causing nearly all the water to run down the sides of hills into the streams. On any steep slope, that would tend to develop a stream by cutting, the amount of material carried down by the water would be so great that it would prevent any deepening of the stream bed. Instead it would fill it up and make it build broad flood plains. Thus in time there would be a general lowering of the whole area, with gentle slopes to the streams.

Origin of "hills of erosion"—In the sand areas, which contain the "hills of erosion," the effect of the water is entirely different. Here the old level of the hilltops will remain almost unchanged, as the rain is absorbed immediately and soaks down to ground water level, and only at this level would streams be formed. Such streams would immediately commence washing away the sands in its way, and on the addition of more rain would deepen its channel, for most of the water would sink through the sands and come into the stream in that manner, instead of running down the slopes and washing in materials to fill up the channel. In such a formation there would be very few surface rivulets to rapidly erode the sides of the hills, so they would naturally waste slowly. In such a manner are most of the hills formed, which at present are the source of the best West Tennessee clays.

Disturbances—A warping has changed the uniformity of the general westward slope of the embayment deposits in Tennessee, so that the same rock that in the southern part near Memphis, may have an elevation of 300 feet above sea level, along the northern part at the Kentucky-Tennessee line, may have an elevation of 450 feet. The elevation which would have maintained along this north and south line, if no warping had occurred, would have been 350 feet. This more elevated area is near that portion of Tennessee which was affected by the New Madrid earthquake of 1811 and 1812. As there is no terracing or ponding in this region, it seems improbable that that region underwent a raise of one hundred feet, such a short time ago, when, from what is known of the topography around there, we have no indication of it. But on the other hand we have indications of disturbances as far back as Eocene times, shown by the sandstone dikes in the Porter's Creek deposits. From this it seems that this elevation and the depression near Memphis were both caused by a series of movements extending from Eocene times to the New Madrid earthquake of 1811 and 1812, each having a movement of several feet.

GENERAL DEVELOPMENT.

The general development of West Tennessee, as a whole, is variable. In spots good crops are raised, though there is hardly a place where the quantity could not be doubled with proper care and attention being given the land. Fertilizers are used but little, and in most places the land is only plowed once a year, in the spring. The crops, in many parts of the area, are not rotated, and in the cotton areas, that commodity has been raised year after year, even before the Civil War. Nearly all of the land in the river bottoms is without any drainage system. This land will make some of the finest farms in the State when a proper system of drainage is employed, but as it is, a great deal of it is swampy and covered with a secondary forest. Away from the larger towns this land can be bought for a few dollars an acre, but the general price, is about $10 to $20. The timber on these lands will generally pay for the expense of clearing. In the few places where drainage work has been done, identical lands sell now up to $100 an acre. Many old cultivated fields, which have been left idle for several years, have been absolutely ruined by the enormous gullies, which have been washed in them, when a little attention at first would have prevented such a state of affairs. A little straw or cane put in the bottom of these gullies would have caught the wash dirt and soon refilled them.

Railway facilities—Portions of West Tennessee have all the railroad facilities that they need, while there are other portions in which transportation facilities are woefully lacking. In general the competition between any of the railroads is so slight that rates are higher than are found further north. This is one of the reasons why no large potteries are located in this State. The following railroads enter West Tennessee: Nashville, Chattanooga & St. Louis; Louisville & Nashville; Illinois Central; Mobile & Ohio; Southern; Kansas City, Memphis & Birmingham; and the Yazoo & Mississippi Valley railroads. The Illinois Central parallels the Mississippi River, and controls all that territory except at the northern boundary around Union City, where the Mobile & Ohio and Nashville, Chattanooga & St. Louis act as feeders, and on the south at Memphis, where all the roads except the Mobile & Ohio connect. The Chicago, Memphis & Gulf is a short line which runs from Tiptonville on the Mississippi River to

Dyersburg, where it connects with the Illinois Central. This road is to be extended in the near future to Jackson, through the towns of Friendship and Alamo, most of the stock having already been subscribed. The Nashville, Chattanooga & St. Louis and Louisville & Nashville cover West Tennessee from east to west, and also along the Tennessee River, while the Illinois Central and Mobile & Ohio run in a general north and south direction through the center, crossing at Jackson. The Southern Railway runs from Memphis along the State boundary, finally crossing into Mississippi.

Character of roads—Except in a few localities the roads in West Tennessee are very poor in winter, being in many places a succession of mudholes. In several localities pikes have been made, notably around Jackson, in Madison County, where they have piked all the roads, for a distance of five miles, and are grading them all over the county. Around Memphis the pikes extend out several miles, there being over 600 miles of novaculite roads in Shelby County, while in several of the smaller towns the roads are piked out for half mile, as at Paris in Henry County, and Humboldt in Gibson County. The roads over the rest of this territory are unimproved except for "corduroying" in some places. The working of the roads is generally done by people who know little about it and consists in running a plow along the side and then pitching the dirt along the side of the road, thus making the road low in the middle and high on both sides. Very seldom do they round the roads. In many places the top soil being sand and clay, is mixed in such proportions as to make a good sand clay road, if the roadbed would only be kept well rounded. The correct proportions for this kind of road is about 85 per cent to 90 per cent sand, and 10 per cent to 15 per cent clay, and as both of these materials are found all over West Tennessee, they could easily have good roads. The pikes are made from novaculite, which is mined in Camden.

Cities and towns—Memphis, with a population of 131,105, is the only city of size in this portion of the State, and is situated in the southwest corner, on the Mississippi River. It is the metropolis of Tennessee, and one of the largest cotton centers, hardwood markets and distributing points in the South. Jackson is the largest of the smaller cities, a thriving town with a population of 15,000, situated in the center of West Tennessee, at the junction of the Mobile & Ohio, Illinois Central and Nashville, Chattanooga & St. Louis railroads. All over the rest of this territory the country is dotted with thriving towns of from 5,000 inhabitants down; of these the most prosperous are Union City and Paris, while the towns of several thousand include

Obion, Dyersburg, Ripley, Covington, Brownsville, Humboldt, Milan, Trenton, Martin, Dresden, McKenzie, Huntingdon, Lexington, Henderson, Selmer, Bolivar, Somerville and Camden. Most of these towns are equipped with waterworks systems and electric lights, and are in a thriving condition.

GEOLOGY OF AREA—STRATIGRAPHY.

General Statement — In this region the deposits consist of sands, gravels and clays, ranging in age from Cretaceous to Recent. The deposition was not continuous, but was broken by several slight uprisings, causing unconformities to exist between several beds. In many places, the sand may be cemented into ferruginous sandstone by the action of the percolating waters. This ironstone or ferruginous sandstone varies from a fraction of an inch to a little over a foot in thickness, and often is found at the base of the sand, lying directly over a clay lense. In this case the descending waters carrying the iron in solution have been stopped by the clay, the iron deposited just above it has formed an ironstone of the sand. As a rule, the overlying sands are easily removed by a shovel from the clay, but in several places the iron has so hardened it that it is very difficult to remove cheaply. In the east in place of an iron sandstone, we often get, where there is gravel, a ferruginous conglomerate, but this lies, as a rule, near the surface, and is easily undermined and washed away, as it does not occur continuously.

FORMATIONS DESCRIBED AND THEIR DESCRIPTION.

The geologic formations of the Gulf embayment of this region given in order from the oldest to the youngest, are the Eutaw sand, Selma clay, and Ripley formations of the Cretaceous; the Porter's Creek and LaGrange of the Eocene; the Lafayette formation of the Pliocene; the Columbia sand, loess and loam of the Pleistocene, and the river alluvium of the Recent age. These lie on the Paleozoic rocks.

PALEOZOIC ROCKS.

These rocks come to the surface along the west bank of the Tennessee River, and as you go westward slope under the embayment deposits, being at a depth of 500 feet at Lexington, and at Memphis, if the same dip continues, and the maximum thickness of the beds be taken, it would be reached at a depth of 2300 feet. At the southern line the rocks belong to the Mississippi series of the Carboniferous,

while in the northern part of Hardin County, and in the Southern part of Benton County, the floor is of Silurian limestones. Again, in the northern part of Benton County the Mississipian series reappear, while still further north in Henry County the beds are of Silurian age.

CRETACEOUS SYSTEM.

EUTAW SAND.

Extent—This deposit is the oldest of the embayment deposits in Tennessee and rests on the rocks of the Paleozoic floor. It outcrops as the eastern edge of the embayment deposits in Hardin and Decatur counties, and the southern edge of Benton County. It extends northward with a slight eastward deflection into those counties from the Mississippi line at which place it has a width of eight miles. From its outcrop it extends westward, going under the other beds and possibly underlying a large share of the region at a depth which increases to the west.

Lithological character—The Eutaw formation is chiefly composed of sands, which are interbedded with thin layers of clay. These beds were laid down in shallow water, where shifting currents predominated, thus making cross bedding a prominent feature in this formation. In an exposure of 200 yards the beds will grade quickly from a sand to a clay and back again, or lenses of clay will appear for short distances. In places the sand and clay alternate in their layers of several feet. On account of these quick variations the thickness of the Eutaw sand varies greatly, and the different beds 25 yards apart will not agree at all. At Parsons, Tenn., just east of town in the Nashville, Chattanooga & St. Louis R. R. cut, at the base, are 3½ ft. of of angular chert pebbles, up to eight inches in diameter overlaid by very thin layers of a dark lignitic shale, slightly sandy. Between these layers, in places, are thin beds of coarse pebbly material 5 inches in diameter, composed of chert. Further on these beds are overlaid by cross bedded sands, which contain some gravel composed of chert, about 1 inch in diameter. In this sand appear in places several layers of leaden or brown clay; on, still further, these beds where they go under the track, are covered by about 20 feet of dark greyish-blue clay, overlaid by about 10 feet of light grade sandy clay.

Section—The best exposure of the Eutaw sands is at Coffee Bluff in Hardin County on the west bank of the Tennessee River, where 215 feet are exposed. The following is an exposure seen on the east side of the road from Lexington to Scott's Hill, in Henderson County, half mile from Scott's Hill:

Section near Scott's Hill, Henderson County.

	Feet	Inches
Dark red sandy clay—case hardened	8	
Lafayette, some gravel mixed in it.		
Ironstone pan		4
Beds of orange sand with several ironstone pans of an inch or two thickness interspersed and little spots of sand from decomposed pyrites	2	4
Ferruginous sandstone, cross bedded	2	
Ferruginous sandstone, cross bedded	3	6
Ferruginous sandstone, cross bedded	3	6
Ironstone ....1 inch to		4
A dirty blue and light grey clay, sandy at top and streaked with yellow and red ....25 to		30
Ironstone pan ....6 inches to		12
Micaceous, very dark grey silty clay with pieces of lignite scattered through it	25	

At this place the road runs 45 degrees west of north.

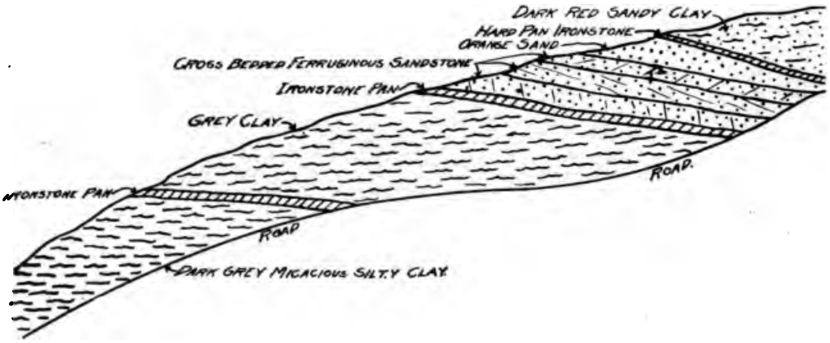


FIG. 1.
ROAD EXPOSURE, SHOWING FORMATIONS NEAR SCOTT'S HILL, TENN.

Thickness and dip—The Eutaw sands dip westward at a low angle and pass beneath the Selma clay. The exact measurements of this bed have never been made, but from the best data available their thickness is thought to be from 275 to 360 feet thick. No record could be gotten of the well which passed through it at Lexington.

SELMA CLAY.

Extent—The Selma clay rests on the Eutaw sands and outcrops west of it in a belt which extends northward about half through the State, with a width of 8 to 10 miles. The Selma clay extends westward under the newer formations to the Mississippi River, where it would be reached at a depth of about 1600 to 1700 feet.

Lithological character—This clay is of a leaden grey or greenish color when dry, but when wet it becomes nearly black. Certain parts get their green color from grains of glauconite which are present. In many places fossil shells are found in abundance, some of them very large. A collection of these was gotten in McNairy County on the road from Guy to Gravel Hill, 2½ miles from Guy. At this place the Selma clay covers the whole surface of the hill. At this same place were found several vertebra of some extinct animal, probably an ichysaurus.

Section—An outcrop of this deposit was visited on the old road which used to go to Shady Hill from Lexington. In Henderson County where the road goes up a hill 1½ miles from Shady Hill, the following section occurs:

Section 1½ miles from Shady Hill.	Feet
Light orange sandy clay	15
Dark green micaceous clay containing many shells	8
Hard shaly limestone containing shell fragments	1½ to 2
Dark green micaceous sandy clay with many large shells	5

This reached to base of hill and under.

From this section it will be seen that certain of the beds are very sandy, but no pure beds of sand have so far been found.

This clay has given especial trouble in "Blue cut" in McNairy County on the Mobile and Ohio Railroad, causing the track to slide. On becoming wet, it takes on a blue color, and becomes very sticky, while on drying it cracks and becomes yellowish.

Thickness—The Selma clay is thickest at the Mississippi line, reaching down about 375 feet, while as it goes north it thins out, until at Lexington it has a thickness of about 100 feet.

RIPLEY SANDS.

Extent—The Ripley sands extend northward entirely across the State, passing through Hardeman, McNairy, Chester, Henderson, Carroll, Benton and Henry counties. The width of its outcrop ranges from about 15 miles in the south to about 6 miles on the northern boundary.

Lithological character—This formation is composed mostly of stratified sands, showing a great variety of colors, such as pink, red, purple, orange or grey. The sands are usually fine gravel, and between them are found beds of grey lignitic or a yellow sandy micaceous clay. In many places these beds are highly ferruginous; having more iron in them than any other of the formations found in West Tennessee, except the Lafayette. Near the surface the iron is peroxidized and gives the sands a very deep red color. The colors of the Ripley and Lafayette are often so similar that great difficulty is experienced in establishing their boundaries when they come in contact.

At certain horizons the iron acts as a cement, and has changed the sands into sandstones and sand ironstones. These ironstones assume many curious shapes, especially that of long hollow tubes, perfectly round, others are flattened, large at one end and small at the other. The variety of forms taken seems unlimited. In the "Big cut" on the Southern Railroad in McNairy County, the pipes are cemented together, forming a honeycombed mass, which protects the underlying sands from erosion. It is these sandstone layers which, by protecting the underlying beds, cause the Ripley sands to extend as an elevated ridge up into the southern part of Tennessee. As before mentioned the rainfall soaks into the sand in much larger proportion than in the clay areas.

Section—The following section is taken from Dr. L. C. Glenn's Water Supply and Irrigation Paper, 164:

Section of Ripley formation near Cypress, Tenn.

	Feet
1. Red case-hardened Lafayette sand and clay, with a few broken pieces of ferruginous sandstone and scattering quartz pebbles marking the contact with the underlying Ripley	8
2. Fine red sand and clay, with rolled clay pellets and thin streaks of white clay	20–25
3. Concretionary tubular sand ironstone in single pipes or in masses of parellel ones, with soft sand cores	2–8
4. Fine variegated sand, having, as a whole, a light greyish color, but showing in detail red, white, brown, yellow and purple streaks or mottling. Case-hardened, so that it breaks off in large masses	20
5. Ferruginous sandstone pipes and fluted masses as above	0–20
6. Fine sand and clay interbedded in thin laminæ; yellow, brown, cream, or grey; sands micaceous; leaf and other plant markings common but indistinct and unidentifiable, exposed down to 15 feet below track level	35

The following section occurs on the road from Scott's Hill to Lexington, on the hill going down to Piney Creek:

Secton on Piney Creek.

	Feet
At the top of hill. Dark orange or blood orange sand, incoherent	15
Layers of slaty shale, interbedded with layers of light orange sandy clay	15–20
Light grey clay, gritty	3½
Going on toward Lexington the road rises about 50 feet in the next mile. Further on blood orange sand interbedded with layers of iron hard pans	20
Further on white sand, with yellow tinge	8
Further on orange sand, case-hardend and clay pellets to the top	15

Dip and thickness—The dip of the Ripley formation is the same as the underlying older beds. Its thickness is not exactly known, but in southern Tennessee it is thought to be about 500 feet.

TERTIARY SYSTEM.

EOCENE SERIES.

PORTER'S CREEK FORMATION.

Extent—The Porter's Creek formation, which is the oldest Eocene deposit of this region, rests unconformably on the underlying Ripley of the Cretaceous. It outcrops directly west of the Ripley sands in a belt from 4 to 8 miles wide, which extends entirely across the State, and dips westward under the newer beds, underlying the State to the Mississippi River, where it is reached at a depth of 1066 feet at Memphis.

Lithological character—This formation is composed of a fine grained clay, grey when dry and micaceous, which on becoming wet, gets very black. It is called "soapstone" all over this region by the inhabitants. In the lower part of this formation the clay is interbedded with a very fine micaceous sand, while in places are found beds of green sand which contain some glauconite.

Sandstone dikes, which vary from a fraction of an inch to several feet intersect these beds of grey clay in some places. As a rule, these dikes are only several inches thick, and may run parallel or in any direction. Some run entirely through the beds, and others ending blindly, or curving and coming back to the main dike.

Section—On the Reynoldsburg road, one mile south of Paris, several of these dikes are exposed in a road cut.

Section of cut 1 mile south of Paris.	Feet	Inches
Light orange sandy clay, very few pebbles Lafayette formation..	5	
Porter's Creek clay, grey, micaceous, with iron streaks and containing perpendicular fissures of very fine micaceous sand from 2-8 inches	5	
Fine micaceous sand from which the dikes run upward		5–8
Porter's Creek grey micaceous clay to road bed	4	

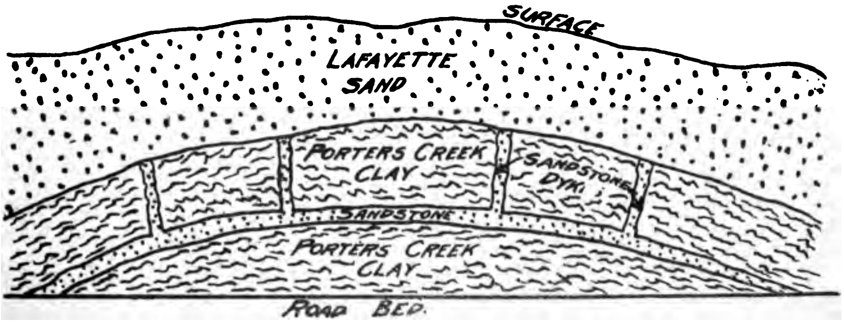


FIG. 2. ROAD EXPOSURE OF PORTER'S CREEK CLAY

All along this road for several miles further on the formation comes into view again and again, overlaid in most places by several feet of Lafayette sands. These fissures seem to be the result of earthquake movements during the Eocene times, the sand being forced up into the fissures along with water, making a quicksand, on account of the particles of mica present. They later on became hardened into sandstone dikes.

Thickness and dip—The dip of the Porter's Creek formation is the same as the underlying Ripley beds. Its thickness as gotten from the well at Jackson is 175 feet, at Memphis it is 155 feet thick.

LAGRANGE FORMATION.

Extent—This formation is the thickest, and covers more area than any other in West Tennessee; although it has the least surface exposure. It is in this formation along its eastern outcrop that all the best clay deposits, especially ball clay, are found. The eastern edge of the LaGrange formation extends from the southwestern part of Hardeman County; then north—northeastward through Chester, Madison, Henderson, Carroll and Henry counties, all of the area of this line is underlaid by the LaGrange at no great depth. This embraces about two thirds the area under discussion. This formation is nearly all covered, to a slight depth along its eastern portion in the foothills, by the Lafayette and the Columbia loess and loam, while in the river bottoms that which has not been cut away is covered by alluvial deposits.

Lithologic character—The LaGrange formation consists of interbedded sands, clays and lignitic material. The largest part is composed of sand, which is mostly fine-grained, though in places there are very coarse beds found, which grade into local gravel deposits. The color of the sand is light yellow or cream, though in places it has streaks of brown or purple. Lignitic material darkens the sand in many places.

The clays of this formation are the best in West Tennessee, grading from fine ball clay down to common brick clay, with all intermediate varieties. In the clay lenses, which occur mostly on the eastern outcrop, there are often streaks of very dark lignitic clay, several feet deep, which grade into a light grey, or change abruptly into a pink or light yellow. The purest clay is found toward the center and bottom of the lenses; that around the edges and top, on account of the impurities in it, such as sand, being used for saggers. These lenses, as a rule, cover several acres only in extent, and are elliptical in shape,

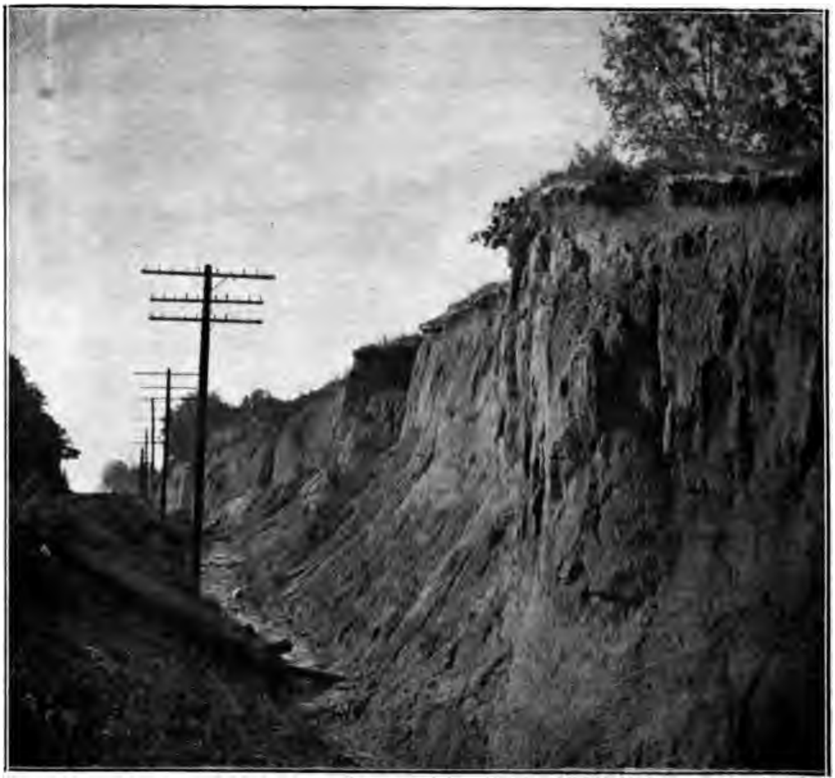


FIG. A. TYPICAL EXPOSURE OF LAFAYETTE FORMATION.
¾ mile west of Camden.

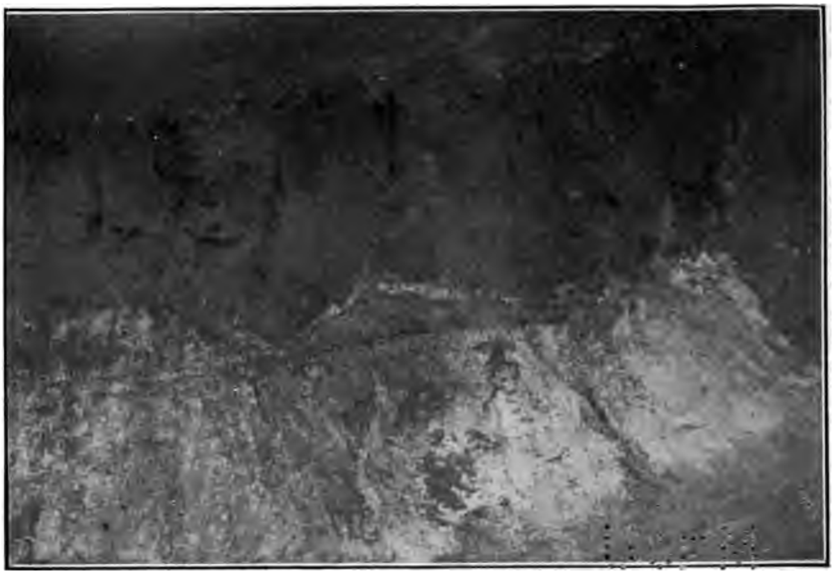


FIG. B. TYPICAL CLAY BLOSSOM IN LAGRANGE, OVERLAID BY LAFAYETTE SANDS.
½ mile south of McKenzie.

with their long axes extending, several degrees west of north, in Henry and Carroll counties, while in Madison and Hardeman counties they extend east of north. These observations refer to the workable deposits in the Ripley as well as the LaGrange. These clays are highly siliceous, especially the fine-grained, white or grey plastic clays. These have resulted from the thorough disintegration of the cherts in the old nearby Paleozoic rocks.

The clay is mined at present principally in Henry and Hardeman counties, although there are small pits in Carroll and Madison counties. In many of the pits are found layers of clay which are full of a great variety of leaf impressions. Some of the leaves are so well preserved that part of the old tissues are still preserved; while others have only the impression of the leaf left in a beautiful pink color. This is caused by waters carrying down iron in solution till the leaf surface is reached, where the iron is dropped as a thin film on its surface. This takes the impression of the leaf and preserves it long after the leaf has rotted away.

In the upper parts of the formation along the Mississippi River are found beds of dark lignitic clays, which are penetrated in wells in that section. At Memphis, there is about 200 feet of blue clay at the top of the formation. As far as known this bed is not continuous.

Lignitic material is found in several places in the LaGrange formation, mostly along its eastern outcrop. These beds are several feet thick and have been used for burning in some places, but in all cases the results have been so poor that the attempt has been given up. All attempts to mine this has been unsuccessful. In the west along the Mississippi River natural exposures are known.

Section—The best view of these beds is gotten at the town of LaGrange in the southeastern part of Fayette County, from which the beds get their name. The town is on a high divide, having a steep slope to the south, which forms the northern side of the valley of Wolf River. The river is a mile away and 200 feet lower.

This steep slope has been greatly eroded, and ravines 100 to 175 feet deep are eating northward, and undermining the south side of LaGrange. The ravines in their numerous ramifications present a fine opportunity for a study of the LaGrange formation, as well as the overlying deposits. The following is a section exposed in a ravine south of town on the road leading south of Wolf River:

Section at LaGrange.

Columbia:	Feet
1. Soft, loose, light-yellow to light gray sands, cross-bedded	15–18
2. Soil layer, dark with organic matter	1

	Feet
Lafayette:	
3. Massive bed of brick-red sand, case-hardened, showing very even top but very irregular lower surface and resting unconformably on the underlying sand	4-15
LaGrange:	
4. Soft cross-bedded sands, mostly fine but in places coarse, of various light colors such as nearly white, light yellow, faint pink, and faint purplish with a few thin crusts and small rounded or short tubular concretions of sand ironstone in places. Near the top there is a clay lens of irregular shape ranging up to 8 or 10 feet thick	100

Fossils—Many plant remains have been found in the clay beds of this formation, especially in the pits at Puryear; Henry Clay Company, near Henry; on the Illinois Central Railroad south of Grand Junction. These fossils determine the LaGrange formation to be of Eocene age.

Thickness—This formation dips from the edge towards the center of the basin. Its thickness at Memphis is 936 feet, while at Jackson, on its eastern edge, only a thickness of 148 feet remain.

The beds were called the Orange sands, as well as LaGrange, by Safford, in his Geology of Tennessee. The term orange has now been discarded on account of the confusion arising from the use of this term.

PLIOCENE SERIES.

LAFAYETTE FORMATION.

Extent—The Lafayette formation extends over all the above mentioned formations, and further eastward over the Palezoic rocks as a thin blanket covering the country. It is composed of sand and gravel and averages less than 20 feet thick, though in places it reaches over 30 feet.

It has been removed where the streams have cut down into the underlying formations, but it is a continuous bed except in places where the Selma or Porter's Creek clays outcrop. In these places as explained on page 5 it has been washed away by erosion, while the sand formations on either side retain it.

Lithologic character—These beds are composed mainly of sand, of a very ferruginous character, giving the formation a dark red or orange color. In places it is cemented into a cross-bedded sandstone, with or without clay pellets and gravel.

In places there are local gravel beds composed of novaculite, quartzite and chert. This phase is found only near the large rivers, as the Mississippi and Tennessee. When the gravel is present the line of unconformity between the Lafayette and underlying formation is easily recognized.

At the base of this formation is often found an ironstone hard pan of from several inches to a foot in thickness, caused by the percolating waters, where they come in contact with clay lenses in the underlying LaGrange.

The red sandy clay, which makes up a great part of this formation, is generally used over this part of the State for making common red bricks. Only the top 6 or 8 feet can be used as it gets too tough below that depth to be worked.

Section—Road exposure 2 miles from Paris on way from the Mandle-Sant pit No. 7.

Section of Lafayette 2 miles northeast of Paris.

	Feet
Lafayette:	
Red sand, with sprinkling of gravel	8
Very dark sand, full of gravel	4
LaGrange:	
Cross-bedded sandstone, red to bottom of gully	15

Thickness—The thickness of these beds is nowhere 50 feet in Tennessee, while in most places only a covering ranging from 2 to 15 feet is found. Their greatest thickness is near the Mississippi River, where they are covered by the Columbia formation.

QUATERNARY SYSTEM.

PLEISTOCENE SERIES.

COLUMBIA FORMATION.

Extent—Under the name Columbia formation are grouped three deposits. The lowest and oldest is a loose sand which is directly over the Lafayette and under the loess, which is the second deposit included. On top of the loess is a loam which overlies the latter where it is found, and extends eastward over the Lafayette as a thin mantle. These deposits are thickest along the Mississippi River where they form the bluffs.

Lithologic character, Sands—Along the Mississippi River, where the loess does not rest unconformably on the Lafayette, there is a loose, soft, light-colored sand. This sand contains rounded chert pebbles, like those in the underlying Lafayette, showing that the deposits is worked over from the older beds. It grades up into the overlying loess without any distinct break, and where the sand is absent the lower part of the loess is sandy in its nature.

Loess—This member extends east from the Mississippi for 20 to 30 miles. It has a thickness of 50 to 75 feet in the river bluffs. From this it thins out to a thin mantle as it goes eastward, and then disappears. On this account no exact eastern boundary can be fixed.

The loess is composed of two phases, a lighter, upper one and a lower, darker member. The lower one is denser and more plastic, and is used to make drainage tile out of, and also brick, while the upper one is porous, with open-texture, and can only be used to make common brick, as it has little placticity. The two members of this loess are well defined in the cut at Curve in Landerdale County, where the Lafayette is overlaid by a loose high-colored sand with gravel from several inches to 3 feet in thickness, and gradually changes into a dark loess, while above this is a distinct layer of light-colored loess.

The loess is considered to be a material composed of finely ground rock flour resulting from glacial erosion. How it was deposited, whether by wind or by water, has not been settled, although the evidence seems to point to a fluviatile origin.

Loam—The loam, which is the third member of the Columbia formation, is found to the east of the loess, and seems to be a continuation of it, though it sometimes overlays it. It is yellow or brownish in color, and in some places becomes an argillaceous sand, and has a general thickness of about 5 feet. It disappears before the limestone rocks are reached to the east. Its eastern edge runs through eastern Hardeman and Madison and western Henry and Carroll counties.

RECENT DEPOSITS.

ALLUVIUM.

Extent—Between the Mississippi River and the bluffs, which form its eastern boundary, there is a flood plain, composed of alluvium deposits. This plain is from 2 to 8 miles wide on the Mississippi. Its main tributaries, the Hatchie, Forked Deer and Obion, have similar valleys of alluvium deposits, which are 1 to 2 miles wide. They are composed of sands and silts brought down by the rivers and deposited on its flood plains, which were carved out of the older formations.

CLAYS OF THE AREA.

DEFINITION OF CLAYS OF AREA.

Kaolin—This is a clay which approaches most nearly the mineral kaolinite in composition. It is usually formed from the decomposition of feldspars; but the few bands of from 1 to 12 inches thick which are found in West Tennessee, must be derived from the chert of the near-by Paleozoic limestone, as there are no feldspars in this neighborhood from which they might have had their origin. The only kaolin seen, was a layer several inches thick, found among the clays in the pit of the Henry Clay Company, near Henry, Henry County, although it occurs in several other places.

Ball clay—Ball clays are those that have a high degree of plasticity, are white after burning, and are of sedimentary origin. They are used on account of their high plasticity as a bond in mixtures of nonplastic clays in the manufacture of white ware. Their tensile strength should be good, and they should be tough and waxy. They should be free or practically so, from iron and grit Their fusibility varies greatly, having a wide range, but refractoriness is to be desired. Those found in West Tennessee generally burn to a dense vitrified body at cone 8 or 9 and show a shrinkage around 15 per cent. They differ from the English ball clays in only having 1 to 2 per cent felspathic matter, while the English contain 15 per cent to 20 per cent. Like the English clays, they have a vitrious fracture. These clays are sometimes washed before being used. Outside of Tennessee other important deposits of ball clay occur at Edgar, Florida; Woodbridge, New Jersey, and Mayfield, Ky.

Sagger clay—The sagger clays of this region are generally gotten from the edges and top of the ball clay pits, where the impurities in the ball clay unfit it for use as such. A sagger clay is so called as it is used to make the receptacles called saggers in which the better grades of ware are enclosed before burning. On this account they should be very plastic and tough, and have little shrinkage, so as to hold together without cracking. They should also be refractory. The raw clay is often mixed with a crushed burnt clay, in the manufacture of the saggers.

Wad—Wad clay is very much like sagger clay, but does not have to be as tough or plastic. It is used for various purposes; for an example, to make a band around the top of a sagger on which another sagger is superimposed. The best wad found in West Tennessee is in Henry County. This wad will not "spit" or "fly," nor will it stick to the saggers.

Potters clay—Clays of this class must have good plasticity. This is necessary in order for the clay to be molded and to retain its shape until the clay is dried and burned.

The following are the properties required in a potters clay, as given by Wheeler:

(1) Eminently plastic, (2) free from coarse sand or other coarse foreign matter, (3) as free from iron as possible, (4) capable of burning to a close incipiently vitrified body at a temperature less than 2200° F., (5) should have a range of at least 200° between the point of incipient and complete vitrification, (6) capable of frying and heating at moderate speed without the employment of grog, (7) tough and

strong body when burned, (8) free from carbonate, sulphates or other salts that are liable to cause blisters in burning.

All of the potters clays found in West Tennessee are along the eastern outcrop of the LaGrange formation, and the western edge of the Ripley sands. Pits are located near McKenzie, Hico, Toone, Pinson and Grand Junction in the LaGrange formation; and at Hollow Rock in the Ripley beds. The potters clay in West Tennessee is commonly used in the manufacture of crocks, churns, jugs, jars, dishes, flower pots, and similar wares.

Common brick—These clays must have sufficient plasticity to be easily molded. Their shrinkage in drying and burning must be low, so that little ware will be lost from warping or cracking. They vary widely, but are usually an impure sandy clay. On account of the amount of iron present they burn to a red color. They should burn to a dense hard body at a low temperature. A high temperature would make them fuse on account of the amount of fluxing matter present. This would prevent them being used for vitrified ware like sewer pipes, etc. The chemical composition except in a wide range is not of a very much importance, but the physical properties will greatly help in determining the methods to be used in manufacturing the brick.

Colors—As mentioned, iron gives a red color to the brick, while lime or magnesia gives cream or buff colors, when present in considerable quantities. The best results are obtained with from 5 per cent to 7% ferric oxide.* Such bricks when underburned have a salmon color, which, on being well burned, becomes red, and on being overburned takes on a reddish purple or black color. Red burning clays are in greatest use for brick making, because they are more common, and also since they generally burn to a dense body at a low temperature.

The common bricks of West Tennessee are made from the surface strippings of the Ripley, Lafayette and Columbia formations, according to which covers the surface at the place of manufacture. Of these beds, the bricks made from the Lafayette should be the best, as these deposits have the best physical properties, but at present more bricks are made from the Columbia loess.

Drainage tile clay—The clays used for drainage tile are similar to those used for common brick. Any plastic clay that will burn to a porous body, that will dry without cracking and that has a fair degree of strength, can be used for such a purpose. A very plastic or sandy clay should be avoided as the former will check and the latter be too weak.

---

*Reis, U. S. Geol. Surv. Prof. Paper No. 11, p. 45.

At present there is only one plant in West Tennessee which manufactures only drain tiles. This is located at Union City, in Obion County, the clay that is used being the dark layer of the Columbia loess. There is any amount of this clay available for such use in all the counties along the Mississippi River, while in the counties further east the same beds of the Lafayette and Ripley formations that are used for brick could be used for tile. The demand for drain tiles has, up to the present, been limited, but with the formation of drainage districts, which has recently been commenced, a great demand for them should come into existence. This industry should therefore at the present time offer a good field for investments.

Fire brick clay—Most good fire bricks are made from mixtures of plastic and non-plastic clays which are very refractory, but sometimes you will find a natural mixture that will give the required result. A fire brick clay must have the power to resist high temperature, a high physical strength, a loose, porous texture to permit of rapid absorption and radiation of heat, and a small amount of shrinkage. The best fire brick clays in West Tennessee come from clay lenses which occur in the lower part of the LaGrange formation, along its eastern outcrop, in Henry, Carroll, Madison and Hardeman counties. Plants are located at Puryear, Henry County, and at Gilmore, Madison County. There are many other places, where deposits were seen in the LaGrange, as well as in the Ripley formations, which could be utilized to make good fire brick.

Such a clay should not fuse under cone 27, while the best fire clays fuse at cone 35. Of the seven samples, which were sent to Heinrich Ries, of Cornell School of Ceramics (p. 30), six of them fused at cone 27 or over. The highest point reached was cone 30 in two samples, one from near Cottage Grove, the other from a road exposure 3 miles north of Milan. The former very fine-grained, and has a total shrinkage of 5 per cent, and a good bonding power, while the latter is coarser grained, has no shrinkage, and bonding power, which does not seem strong.

According to the conditions under which a fire brick is to be used, they must have different properties. For abrasive resistance they must be hard; for corrosion, dense; while to resist high heats and changes of temperature, porosity and coarseness are important.

Impure fire clays have been used in other States for sewer pipes. They make a good light-colored article, but it does not sell as readily as the dark-colored ones. This can be remedied by mixing a considerable amount of iron with the clay. A plant of this kind could be profitably operated in this part of the State, as no sewer pipe is made there now.

MIXTURES OF CLAYS USED IN CERTAIN MANUFACTURED WARES.

Electrical Ware—In manufacturing this ware a mixture of ball clay, kaolin, feldspar and quartz is used. The West Tennessee ball clays, which vitrify at cone 8 or 9, are used for this ware. Refractory substances are mixed with this, so as to raise the point of vitrification to cone 12, which is considered the best temperature.

Porcelain or china—This is made of a mixture of clays and minerals. Porcelains are divided into two groups, those of soft body, and those of hard body, with vitrious fracture. In the soft ware calcined bones or lime phosphate is used as one of the ingredients, while in the other ware feldspar is used as flux. The other ingredients in both groups are ball clays, kaolins and quartz. Ball clays from Henry County are used in ware of this class.

White ware—This is made of the same mixtures as porcelain, the only difference being that the porcelain is burned at a higher temperature.

Sanitary ware—Ingredients and manufacture is practically the same as for white ware.

Stoneware—In this ware the clay is used by itself, just as it is taken from the pit. The clay is tempered, and the ware is molded on a potters wheel or in plaster of paris molds. The ware is then, after drying, glazed with a slip clay. A clay that produces a brown glaze, which is gotten from Albany, New York, is most commonly used. The articles are dipped in the liquid clay. One firing only is required, as the body of the ware gains the required hardness at the fusing temperature of the glaze. The temperature of the kiln varies from cone 6 to 9. Clays of this class are abundant in West Tennessee. (See p. 19.)

CHARACTER OF DEPOSITS.

The clay deposits of West Tennessee are all of sedimentary origin and are gotten from the decomposition of the chert in the nearby Paleozoic limestones. The sedimentary clays are generally classified according to the conditions under which they were formed. The following conditions of deposit are found in West Tennessee:

1. Embayment (Fresh water) clays.
   Embayment (Brackish) clays
   Embayment (Marine) clays.
2. Glacial clays.
3. Lacrustine clays.
4. Floodplain and terrace clays.

Embayment clays—All the best deposits of this region come under this general head. They are divided into three divisions, according to the conditions of the water by which they are laid down. The streams carrying sediments empty into these embayments and the sediments are deposited near the shore line as bars running parallel with the shore*

These bars form the clay lenses as we find them at present. These lenses are longer than wide, and in Henry and Carroll counties the deposits which have been worked extend about 20 degrees west of north; while further south in Madison and Hardeman counties the lenses extend 15 to 25 degrees east of north. These deposits cover from 3 to 12 acres in extent, and the land over them is generally level, and often observed forming a flat area which extends several rods beyond the clay to the northwest. The signs which as a rule indicate clay deposits are a sandy top soil which is always moist and hillside springs. No boring has been done except where clay "blossoms" have already been found.

Deposits in fresh water—The embayment deposits laid down under fresh water conditions were the Ripley of the Cretaceous period and the Lafayette of the Pliocene period. Of these two deposits we find the best clay in the Ripley, where it is gotten from elliptical lenses. covering several acres in extent. It consists of ball, sagger, potter and fire clay, which are mined especially east of Paris and around Hollow Rock. The clays of the Lafayette are not found in lenses, and none of them are white. Only the surface layers down to 6 feet are used to make common brick. The red clays are used wherever the demand is sufficient or the railroad rates favorable for shipping. These clays furnish all the bricks that are made in the central counties, as Fayette, Haywood, Crockett, Gibson and Weakley, and the counties east of them.

---

*While mud laden fresh water coming into the sea will often deposit the mud as a bar along the belt where the fresh waters ride on to the heavier salt water, the frequent presence of leaves in these clays, entirely unbroken and unworn, indicate that the trees must have grown close to the point of the deposition of the clay, so near that the leaves could be carried by the wind and dropped into the water where the clay was accumulating. It would therefore seem possible that the clays accumulated in lagoons, or basins, on the shore formed by the irregular action of the waves, or in the irregularities of a subsiding surface, which being in the nature of pools or ponds soon filled with mud from the surrounding surface, and were later buried beneath sand deposits laid down on the encroaching shore. For the purposes of this report detailed studies of the nature and origin of these clay lenses were not made. But the close resemblance between the succession of strata in the pits being worked, and the filled glacial lakes of the northern United States and the basal coal beds of the eastern coal fields is of interest. In each case a depression or basin has first more or less filled with clay, and then been succeeded by vegetable growth, resulting in the coal beds of the Carboniferous. in the peat marshes of the lake region, and in black clay or lignite, which in so many of the pits overlies the clay.—G. H. A.

Deposited in brackish water—The best and most extensive clays were deposited under these conditions, being those that are contained in the Eutaw sands are of Cretaceous age and the LaGrange sands are of the Eocene. It is in the LaGrange that most of the large pits of West Tennessee are located.

In West Tennessee during the deposition of the LaGrange beds, the waters were very shallow. The presence of strong shore currents, in places, has ruined the commercial value of many of the clay lenses, by causing such a rapid variation of the clay that no two yards are alike. Often leaves and other organic matter mined occurs in the clay, which gives it a dark brown or black color. When this organic matter can be burned out, it does not effect the value of the clay, but often when the quantity is large, the clay will burn to a buff instead of white color. Another impurity is iron, which when found in sufficient quantities renders a ball clay worthless, except for use in saggers; but a white clay that has a light pink tint is generally all right, for that will disappear in the burning, and leave a white product. Grit is another impurity, which renders a fine clay useless unless it is washed, and it is found on the edges and at the top of the deposit. On this account samples of clay should always be taken from near the bottom and as far in the hill as possible. Even then the clay, when mined, should be expected to run purer further into the deposit. These clay lenses cover from 3 to 10 acres and have a thickness at their center of about 5 to 10 feet which thins out towards the edge.

The principal pits in the LaGrange formation are in Henry County around Paris, while pottery pits are located near McKenzie, Hico, Toone, Pinson and Grand Junction.

No deposits of clay in the Eutaw are known to be of commercial value, on account of their small extent and changing conditions.

Deposits under marine conditions—At present no clays are used from the Selma or Porter's Creek formation. The Selma might make a good common brick or drainage tile, but on account of its outcrop being away from any railroad it has not been used.

The Porter's Creek formation has not been found to contain clay lenses of workable size. From the character of this "soapstone," as it is called, it would seem that a good paving brick could be made. Tests along this line would probably show this to be the case.

Glacial clays—Under this term is included the loess of the Columbia formation, which, whether deposited under water or by air, was made from the materials brought down into southern Illinois by the glaciers.

This loess is used for making common and pressed brick, and drainage tile, and is of two varieties—the light, porous material which is not very plastic, and the darker, which is denser and very plastic, out of which the tiles are made. The loess is in a continuous bed extending back from the Mississippi River bluffs, which are composed of it, and is mined wherever there is a local demand for brick, or where the railroad rates are cheap enough to ship the made articles. It is only mined down 5 or 6 feet, as below that it becomes too tough to be worked.

The loess is used in the following counties: Shelby, Tipton, Lauderdale, Dyer, Obion and in the western parts of Weakley, Gibson, Crockett, Haywood and Fayette.

3 *Lacrustine clays*—No deposits of this kind are found in West Tennessee.

4 *Floodplain and terrace clays*—The floodplain and terrace deposits are not generally used, but they have been worked for brick in a few places, where they are convenient. They are only found along the Mississippi River, and a short distance up its main tributaries, such as the Obion, Forked Deer, Hatchie and Wolf, where it forms their floodplains.

STRATIGRAPHIC POSITION OF DEPOSITS.

Eutaw sands—So far no beds or lenses of clay have been worked in the Eutaw. All through these deposits are thin layers of clay, alternating with sand. In many places a pure clay will be found, but in several feet it will grade to a pure sand. On this account these beds will probably never be of economic value.

Selma clays—This deposit is composed primarily of clays, which in places becomes sandy, but no pure sands are found. This clay contains a considerable amount of lime, and on this account is not worked for brick.

Ripley formation—There are only two places where pits in this deposit are worked, one near India, in Henry County, the other just east of Hollow Rock, in Carroll County. The pits at both places are situated near the contact of the Ripley with the overlying Porter's Creek formation, thus making the known clay deposits occur in the very uppermost part of the Ripley beds. At two other places were small nonworkable deposits found; around Lexington, where they were small and sandy, and at Selmer, where a band of dark leaden grey clay one foot thick was found in spots. These two places are situated where the base of the Ripley outcrops and indicate that no good clay lenses occur in the base of the formation. It may be that clay is only found in the Ripley beds in the northern half of the State in its upper part;

and that none exists in any part of this formation in the southern half of the State in workable quantities. Still it seems that any prospecting done along its western outcrop from Hollow Rock south to the State line would, in some places, disclose workable clay lenses.

Porter's Creek formation—No beds or pockets of clay that are worked are found in the formation. The upper part of this formation is composed of a bed of dark grey clay, which might be worked for fireproofing. No fireproofing tiles are made in West Tennessee, but a good market for such could be found.

The following analyses of the Ripley and Porter's Creek formations will give an idea of their chemical character. They have been taken from reports of the Kentucky and Mississippi Geological Surveys. In Kentucky the Porter's Creek clay came from Paris Bridge, Murray, and the Ripley clay from 6 miles east of Murrey-Jobes and Willoughby. In Mississippi the Porter's Creek clay came from Oktibbehe County. and the Ripley from Ripley, Miss.:

Table of analyses of Porter's Creek and Ripley formations.

	Porter's Creek		Ripley	
	1 Ky.	2 Miss.	1 Ky.	2 Miss.
Silica	66.38	65.60	54.14	67.10
Alumina	16.48	10.50	32.14	10.96
Iron Peroxide	3.5	7.20	1.04	6.60
Lime	.213	1.12	.011	1.87
Magnesia	.497	.60	.032	.54
Potash	.928		.965	
Soda	.228		.468	
Water, expelled 380° F	11.774		11.204	
Volatile Matter (Co)		9.05		3.96
Moisture (H O)		4.95		8.23
Sulphur trioxide				.51
	100.00	99.98	100.00	99.77

LaGrange formation—The deposits of this formation all occur in its beds, which are near the surface only at its eastern outcrop in Henry, Carroll, Madison and Hardeman counties. Further west the lower part of the LaGrange formation is to deep to permit profitable working of the clay deposits which we still find evidences of in deep well borings. All the deposits which are now worked occur within 15 miles of its eastern outcrop. No surface blossoms were found west of that. As before noted, many of the deposits are elliptical in shape, and in the northern half of the State extend a few degrees west of north, while in the southern half the longer axis lies several degrees east of north. (For location of pits, see page 27.)

---

(1) Kentucky Geological Survey Bull. No. 6, p. 104.

(2) Mississippi Geological Survey Bull. No. 1, pp. 159-60

Lafayette formation—The only clays used from this formation are the surface ones, which extend over the country as a bedded deposit, sandy in places. They are mined anywhere that the conditions are favorable. Only the upper four to ten feet can be used for brick, as below that the clays become too tough.

Columbia formation—Only the light and dark loess deposits, which cover the western part of West Tennessee as a surface deposit, are used in brick and the tile making. These beds can only be used from the surface to a depth of from 4 to 12 feet, according to local conditions, as they become too tough deeper down.

GENERAL DISTRIBUTION OF DEPOSITS.

Only the formation which contain lenses or beds of clay which are now utilized in an economic way will be discussed under this heading.

Ripley formation—At present only two areas contain pits of any importance in this formation. Near India, which is 5 miles northeast of Paris, Henry County, there are two pits operated, which are owned by the Mandle-Sant Clay Company, of St. Louis, Mo. The other place is around the town of Hollow Rock, Carroll County, on the Nashville, Chattanooga & St. Louis Railway. West of town are 3 pits, about one-half mile apart, and also south of town there is one pit. They ship all the clay mined to potteries located in Nashville, Tenn. Outside of these two localities no deposits are worked in the Ripley formation.

LaGrange formation—Pits are located in this formation in Henry, Carroll, Madison, Gibson, Hardeman and Fayette counties. In Henry County they occur along the State line to within about 6 miles of McKenzie, the best pits being located near Whitlock and Henry. More clay is mined in this county than all the rest of West Tennessee. Carroll County has a few pits located near Hico, which are not now worked. Several goods outcrops were found about 4 miles west of Trezevant. No clay is mined in this county for anything except brick. Madison County has pits worked at Gilmore for fire brick and at Pinson for potters clay. A pottery is located there. Gibson County has some good deposits of fire clay located along the railroad near Milan and Humboldt, but none of them are worked. Hardeman County has pits and potteries located at Toone, in the northern, and at Grand Junction, in the southern part, where there are several old pits located. At Bolivar on the West Tennessee Asylum land, a good outcrop of very plastic clay was found. On the Southern Railway, about 3 miles east of Moscow, in Fayette County, there is a large lens which should make a good fire brick.

The best clay is found in Henry County where there are several mines of very fine ball clay, which is shipped to Kentucky, Ohio, New York and Connecticut. Clay has been gotten from near Trezevant in Carroll County, and near Bolivar, which seems to correspond very nearly to the Henry County ball clay, but no tests have been made of them.

Lafayette formation—This surface formation is used in the manufacture of brick at nearly all of the towns in West Tennessee, where it is overlaid. The following places have good size plants located at them: McKenzie, Milan, Humboldt, Brownsville, Trenton, Somerville, Whiteville, Bolivar and Jackson. It is only used in the central counties, for further west it is overlaid by the Columbia formation, which is there used for the same purpose.

Columbia formation—In the western counties where this is the surface formation, the loess is used in the manufacture of bricks. The following counties make brick from this formation: Shelby, Tipton, Lauderdale, Dyer and Weakley counties. At Union City, the only tile plant in that part of the State makes their product from these clays, while brick plants are located at Union City, Martin, Rives, Obion, Dyersburg, Covington and Memphis.

Resume—Any place in West Tennessee has surface clays suitable for brick making, while the fine white plastic clays occur in two belts, the principal one extending across the State from Paris in the north to Grand Junction in the South; the other and smaller band extends from India, 5 miles east of Paris, to Lexington on the south.

TESTS ON SHRINKAGE, FUSIBILITY AND COLOR OF WEST TENNESSEE CLAYS.

All of the following tests were made from unworked clay deposits, most of which were situated in the LaGrange formation. Typical samples of clay taken from the Porter's Creek, Ripley, Selma and Eutaw formations were also tested, from which a general idea may be gotten of the character of these clays.

Methods employed in making the tests—The clay was ground up very fine on an iron slab, then mixed with just enough water to work it to a plastic condition, the working being done by hand. It was then pressed in a small mold. The mold consisted of a steel ring 5.05 centimeters in diameter and .5 centimeters thick, which was broken on one side, and held in a clamp. To fill the mold it was placed on a plaster of paris block, pressed full of clay and smoothed off on top by running a steel spatula over the top of the ring. The moisture was absorbed by the plaster of paris, the clamp loosened and the mold removed. The clay was air-dried over night, and the air shrinkage measured.

The burning was done in a Seger furnace, in which the highest temperature that could be gotten was of cone 15, which was reached after a five-hour burn.

The tests are given under the headings of the counties from which they were gotten:

LOCALITY	Air Shrink. %	Total Shrink. %	Color	Temp. of burn. Fahr.	Probabe use
CARROLL COUNTY.					
Old mine, near Hico	a 3½	10	White	2390°	Stoneware
4 mi. S. of Huntingdon	b 4	14½	Dark grey	*2500°	Stoneware
2 mi. S. of McLemoresville	c 3½	6	Buff	2450°	Fire brick
1½ mi. W. of Trezevant	a 4½	10	Light cream	2335°	Stoneware
4 mi. W. of Trezevant (J. O. Smith)	b 6	8½	Light cream	2460°	Fire brick
4 mi. W. of Trezevant (Wm. Watkins)	a 4	16	Light grey	*2335°	Ball clay
4½ mi. E. of Trezevant	a 4½	14	Dark grey	*2335°	Sagger clay
DECATUR COUNTY.					
½ mi. E. of Parsons	b 3½	7	Dark brown	*2426°	None
FAYETTE COUNTY.					
1½ mi. N. of Grand Junction	a 7½	14½	Greyish brown	2282?	Stoneware
Davenport pit, LaGrange	a 4½	12	Buff	*2318°	Sewer pipe
2 mi. E. of Moscow on Ry.	b 4	10	Dark cream	*2600°	Fire brick
GIBSON COUNTY.					
2 mi. E. of Humboldt	a 5	10	Light cream	2282°	Stoneware
1 mi. S. W. of Milan	b 5½	10	Light cream	2426°	Stoneware
1½ mi. S. W. Milan	c 3	3½	Dark cream	2500°	Fire brick
3 mi. W. Milan	b 4½	11½	White	2426°	Stoneware
3 mi. N. Milan	c 0	0	White	2606°	None (mostly sand)
HARDEMAN COUNTY.					
At Bolivar Asylum	a 5½	16	Light grey	*2335°	Ball clay
HENDERSON COUNTY.					
3 mi. W. Lexington (Sanford)	b 6½	11	Light grey	*2390°	Stoneware
Road exposure at Scott's Hill	b 6½	7	Buff	2282°	Fireproofing
Same mixed, half sawdust	c 2	12½	Buff	2370°	Fireproofing
HENRY COUNTY.					
½ mi. N. of Cottage Grove	c 1½	4	White	2606°	Fire brick
Porter's Creek clay, ¼ mi. S. Paris	c 2	6½	Light cream specked	2370°	Fireproofing
Ripley clay, 3 mi. E. Paris	c 5	10½	Light cream	2370°	Brick
½ mi. S. W. Mandle pit No. 7	a 3	8½	Light cream	2425°	Sagger
MADISON COUNTY.					
Brown Church Road, Jackson	a 6	18	Light cream	2425°	Ball clay
Spring Creek Road, Jackson	c 3½	6	Light cream specked	2500°	Brick
Spring Creek Road by bridge	c 7½	14½	Cream, speck'd	*2425°	Brick
1½ mi. E. Malesus	b 3	11	Light grey	2282°	Stoneware
1 mi. W. of Medon	c 5	14	Light grey	*2600°	Fire clay
2½ mi. S. Medon	c 4	12	Light cream	2335°	Fire brick
Same, Bolivar Road	b 4½	10	Creamy grey	*2600°	Fire brick
Davis pit, near Pinson	b 6½	12	Light cream	2390°	Stoneware
Allen pit, near Pinson	b 8½	11½	Buff	*2318°	Stoneware

a—very plastic. b—plastic. c—slightly plastic. *—slightly vitrified.

Seven of the preceding samples which contained clay, which seemed especially adapted to making a good fire brick, were sent to Heinrich Ries of the Cornell School of Ceramics to be tested for their fusibility.

In making these high temperature tests the clay is made into small cones identical in shape and size to the Seger cones. The following results were gotten:

CARROLL COUNTY.	Cone of Fusion	Temperature Fahr.
2 miles south of McLemoresville	26	3002°
4 miles west of Trezevant (J. B. Smith)..	29	3110°
FAYETTE COUNTY.		
2 miles east of Moscow on railroad	27	3038°
GIBSON COUNTY.		
1½ miles southwest of Milan	27	3038°
3 miles north of Milan	30	3146°
HENRY COUNTY.		
½ mile north of Cottage Grove	30	3146°
MADISON COUNTY.		
2½ miles south of Medon	27	3038°

MINING, PREPARATION AND MANUFACTURE.

As this Survey intends to make a clay report of the three divisions of the State, no exhaustive discussion of the technology of clays will be given in this, the first bulletin of the three. Only enough of the technology will be given to allow of a complete understanding of the few technical terms used herein.

MINING.

Brick clay—These clays are mined in most cases directly from the surface down until they become too tough to be molded by the machine, which depth varies in the Lafayette clay from 4 to 10 feet, while in the Columbia formation, the loess is as a rule worked down to about 5 feet, though some cases were heard of where it was said to be mined to a depth of 15 feet. In certain places a foot or two of the surface clays are thrown aside. The grey clays which are used in brick manufacturing are found in lenses from which the overburden has to be removed by iron scrapers. The brick clays are usually dug with a pick and taken to the nearby machine or the storage sheds by iron scrapers, such as are commonly used for grading.

Potters clay—The white, grey and pink plastic clays all occur in lenses covered by an overburden which varies from 2 to 30 feet, which is removed by iron scrapers, or steam shovels, according to the policy of the operating company. In most cases the scraping method is declared to be the most economical. The clay itself is blasted to loosen it, and then dug out with picks and spades.

For hauling the clay some of the pits have narrow gauge roads running down in them, which connect with the railroad. The clay in such cases is loaded into small dump cars, which are carried by "Dinkies" to the railroad, where it is piled in sheds, awaiting its loading and shipping over the railroad. Where narrow gauge roads are not used the clay is hauled out of the pit in two-horse wagons, to a nearby railroad switch, where it is loaded or stored in sheds.

GRINDING.

The dry pan and ball mill are the pulverizers most commonly employed, but in West Tennessee no ball mills are used, and only a few dry pans, which are used in connection with dry press brick machines.

Dry pan—This machine consists of a revolving metal pan, over the bottom of which roll two heavy wheels or mullers. The central part of the pan is solid, and over this the mullers roll, while the outer side of the bottom of the pan is perforated, and over it the crushed clay is spread by centrifugal force. The small particles sift through, while the large ones are thrown back in front of the mullers by means of scrapers. The pans vary from 5 to 9 feet in diameter, and are about 14 inches high. Screens may be had with either large or small perforations. Dry pans made by the Frost Manufacturing Company, Galesburg, Ill., are in use.

CONVEYERS.

Conveyers are used for carrying the mud from the soaking pits to the brick machines, or to carry the dry pulverized clay from the dry pan to screens, where it is sifted, before falling into the top of the dry press brick machine.

The conveyor may be a belt or rubber apron with flanges on the side to prevent the clay from falling off. Where the conveyer has a steep inclination, cross pieces may be added, and when vertical a series of iron buckets fastened to a chain or belt are used.

SCREENS.

The clay that comes from the dry pan is not uniform enough in size to be passed directly to the dry press machine. The grading is accomplished by screens which return all clay larger than a certain size to be reground.

The screens are made with various size openings, or have different meshes—according to what size particles must pass through them. Screens are made in three general types: inclined stationary, inclined vibrating and rotary.

TEMPERING.

The crushing methods that have been mentioned are used with dry clays, with the object of reducing them to uniform size. The tempering, as it is called, is necessary to develop the plasticity of the clay, and is accomplished by mixing the clay with water, and making the entire mass have a uniform composition. The process may be accomplished several different ways.

Soaking pits—In making soft mud bricks the clay is put into pits, usually 4 feet deep, and holding enough mud to make 20,000 brick. It is then mixed with water and kept in the soaking pits for 24 hours.

Wet pan—It is constructed very similar to the dry pan, except that the bottom is solid instead of perforated. It is used in West Tennessee to both pulverize and temper the clay used in potteries. The clay is shoveled into the pans, and water added to bring it to the proper consistency. It is then thoroughly ground and mixed. The tempered clay is removed—by means of a long-handled shovel mounted on a pivot near the pan—while the machine is in motion, after which another charge is added and the operation repeated. The wet pan is smaller than the dry, but it performs the two operations of grinding and tempering together. A wet pan manufactured by Turner, Vaughn, Taylor & Co., Cuyahoga Falls, Ohio, is used in some of the potteries.

Pug mill—It is used primarily with brick clays in the manufacture of which it is used very extensively.

The pug mill consists of a semi-cylindrical trough of steel, having a length of from 3 to 16 feet, with an average of 8 feet. Through this a shaft revolves, which has a series of knives set spirally on it, and at an angle to its plane of revolution. The angle of the knives and the rate of revolution determines the rate at which the clay will be carried forward. Its discharge is regulated by a movable gate. The mill is usually made horizontal, and either as a part of the brick machine or separate from it.

In places, home-made wooden vertical pug mills, which are turned by a horse, are used in making soft mud brick. The shaft is a small tree with wooden bars sticking out at right angles, while the casing for the shaft is square and made of rough boards.

The clay is fed into the hopper of the pug mill and sufficient water added to bring to the right consistency for molding. This must be done by an experienced man, for if too little water is added the clay bar will be cracked as it comes from the machine, or if too much water is added the brick will be so soft that it will be easily injured in handling, as well as taking long time to dry, and having more shrinkage than proper.

The following makes were seen in use: Eagle Soft Mud Brick Machine, R. Craycroft, Vandalia, Ill., Iron Standard Brick Machine, No. 289, Horton Mfg. Co., Painesville, Ohio; Success Soft Mud Machine, Success Brick Mfg. Company, Memphis, Tenn.; No. 24-SSS Stiffmud Brick Machine, Arnold-Creager Co., New London, Ohio; No. 3 Stiff Mud, J. C. Steele, Statesville, N. C.; Hercules Soft Mud Machine, Horton Mfg. Company, Raymond, Ohio; J. D. Fate Machine No. 9 A Stiff Mud, H. Brewer & Co., Tecumseh, Mich.; Soft Mud Machine, Hardin Mfg. Company, and Grand Automatic Soft Mud, John Creiger.

Chaser mills—These mills are used in several brick plants where hand molding is used. They consist of a circular pit, about 18 inches deep, and about 18 feet in diameter, in which revolves a frame bearing two narrow iron wheels, 30 to 36 inches in diameter. As this frame revolves, the wheels by means of gearing travel from the center to the circumference of the pan and back again. The clay and water is placed in the pan, and the wheels grind and temper it. A wheel manufactured by C. W. Raymond, Dayton, Ohio, is the one commonly used.

MOLDING.

There are two processes used in the molding of brick, the wet method, where water is mixed with the clay, and the dry method, where no water is used, the clay being pressed in a dry condition. The cheapest way on a small scale is hand molding, which method is employed in five plants in West Tennessee. Next in order comes the soft mud machine, which is used in ten plants, and vies in popularity with the stiff mud machine, which is used in seven different plants. The most expensive machine is the Dry Press, which is the only machine making a smooth press brick. It is in operation in five plants in West Tennessee. Most of the three different machines in use have a daily capacity of 20,000 bricks.

Soft mud—In this method the clay is mixed with water to the consistency of soft mud and pressed into wooden molds. The molds are sanded to prevent the clay sticking to them, and the molding is done either by hand or by machinery. In hand molding a lump of clay is forced into the mold, pressed down and the excess of clay cut off by means of a fine wire. The mold is then turned over, and the brick dumped out. In West Tenn. one molder will make 6,000 brick a day. The soft mud machine consists of an upright box in which revolves a verticle shaft with several blades, while there is a curved arm attached to the bottom of the shaft to force the clay into the press box. The mold, which has six divisions, is sanded and pushed under the press box, then the plunger descends and forces the soft clay into it, then the mold moves forward automatically to the delivery table, while another sanded mold takes its place.

Stiff mud—In this method the clay is tempered with less water, and is therefore much stiffer. The process consists in taking the clay and forcing it through a rectangular die in the form of a bar, which is then cut into bricks. The "Auger" type of machine is used in West Tennessee. It consists of a cylinder open at one end and tapering to a rectangular die, with a cross section the size of the side or end of the brick. The inside of the cylinder is made like a pug mill with the addition at the small end of a tapering screw. The die is heated by steam, and oil is used on its inner side to facilitate the flow of the clay.

The tempered clay is put in the hopper and moved forward by the arms and then pushed through the die by the screw. The bar of clay runs out on a cutting table and is cut into brick by a number of parallel steel wires.

The process is good, when properly used, but the clay should be thoroughly tempered before molding.

Dry press—In this method the clay is ground and screened and then pressed into steel molds in a dry condition. The molding machine consists of a steel frame with a delivery table 3 feet above the ground and a press box sunk into the rear of it. The charger, which consists of a frame work which slides back and forth over the molds, is connected with the clay hopper by a canvas tube. It is filled when it moves back, at which time the plunger descends pressing down the clay in the molds, while at the same time the bottom of the mold rises slightly, subjecting the clay to greater pressure. The plunger then rises, also the mold, which ascends to the level of the delivery table. The mold is then pushed forward by the charger as it comes forward to refill the molds.

The faces of the mold are made of hard steel and heated to prevent sticking of the clay. They also have small air holes in them to prevent the escape of air, which becomes imprisoned in the clay when the plunger descends. Two machines of this class were seen in use—a Burg Dry Press, made by Anderson Foundry & Machine Works, Anderson, Ind., and a Reliance Dry Press, made by Reliance Machine & Tool Works, St. Louis, Mo.

At one place in West Tennessee an hydraulic dry press is used. In this the pressure is produced by a pair of hydraulic rams acting gently and applied from above and below.

The advantages of this process are that in one process a brick with smooth faces and sharp edges is made, also that no preliminary drying is necessary before burning, the bricks being placed directly in the kiln.

Repress machine—Soft and stiff mud brick are often improved in appearance by repressing. The repress consists of a steel mold box, having a movable top and bottom. The green brick are placed in it, and pressure applied. This reforms the brick slightly and makes a poor front brick.

Turning—This is done in the potteries of West Tennessee on a rapidly revolving horizontal wheel, called a "kicker," as it is worked by a foot pedal. The potter takes the lump of clay and places it on the rapidly revolving disc; wetting the surface with his hands he slowly and gradually works the revolving mass into the required form. The ware is detatched from the wheel by running a thin wire underneath it, and is set aside to dry. Crocks, jugs and similar ware are turned.

Repressing—Instead of turning, the ware is often made in plaster of paris molds, made in two or three pieces, whose inner surface conforms to the outer surface of the ware.

DRYING.

The drying is done under outdoor racks, no plants at present being equipped with drying apparatus. This permits working only in the summer, except where dry press machines are used, for then the brick can be placed directly in the kiln without a preliminary drying. The installation of drying machinery is very expensive, and increases the cost of the brick. A sun-dried brick is therefore cheaper. The bricks are dried, according to their composition, from 2 to 8 days, 7 days being the general time taken. Those bricks made from the Lafayette clays take less time than those using the Columbia loess or loam.

BURNING.

Difference in cost—The bricks are burned in a variety of kilns, four types being in use; the scove and Dutch updraft, the continuous and the downdraft. There are thirteen plants using Dutch kilns, with a total of forty-one such kilns in operation. They reduce the amount of fuel necessary to burn brick. In one such kiln is required twenty-five hundredths of a ton of coal, fourteen hundredths of a ton of coke, and seven hundredths of a cord of wood for burning 1,000 brick, making the cost about $1.35 per 1,000 brick for fuel.

The downdraft kilns are rectangular and beehive in shape, only one of the former kind being in use. There are seven plants using intermittent downdraft kilns, with a total of twenty-two such kilns in operation. This type of kiln reduced still more the cost of burning. In one such kiln in West Tennessee, it required twenty-three hundredths of a ton of coal, eleven hundredths of a ton of coke, and five hundredths of a cord of wood per 1,000 brick, making the fuel cost about 95 cents a 1,000 brick. This shows a saving in cost of fuel of 40 cents a 1,000 brick, which is partly eaten up by the extra cost of downdraft kiln, but even then there is a great saving. No figures could be gotten on the continuous kiln, but the cost is probably slightly reduced in this type.

The coal used in the kilns in the northern part of the State is gotten from Kentucky, and in the southern part from Alabama. Tennessee coal is not used. Where patented burning systems are used, a poor coal can be gotten which costs about $1.60 a ton delivered, but for ordinary burning the coal used costs from $2,25 to $3.25 a ton delivered, according to the distance hauled. Where coal only is used in burning, it requires about one-half a ton per 1,000 brick. This is the case only where a patented system of burning is used. The cost for fuel in this case is about 80 cents per thousand brick.

Coke is used only in conjunction with wood to dry out the brick before burning. It costs from $3.75 to $4.00 a ton delivered, and from one-tenth to one-half ton per 1,000 brick are used according to the type of kiln.

Wood is used for drying out the brick by itself or in connection with coke; or is used for both the drying and burning. It costs from $1.25 to $3.00 a cord delivered. In many places slabs from saw mills are used. In drying out in conjunction with coke, from one-tenth to five hundredths of a cord are used per 1,000 brick, while for drying and burning just with wood, it requires about one cord of wood per 1,000 brick.

The cheapest burn with coal, which was found in West Tennessee, was 80 cents per 1,000 brick, with wood, $1.25 per 1,000 brick, and with a mixture of coal, coke and wood, 94 cents per 1,000 brick. The highest cost of fuel that was found in burning was $3.28 per 1,000 brick, where they used coal, coke and wood.

Scove kiln—This is the simplest type of updraft kiln, and is of temporary character. In West Tennessee the brick are set in large rectangular masses about 40 bricks high. In piling up the bricks a series of parallel arches are left running through the mass from side to side, with their centers 27 inches apart. These are the fire holes and are called "eyes." The bricks are surrounded by a wall of under burned brick 13 inches at the base and 9 inches at the top, which is plastered over with wet mud. (See plate 5, Fig A.)

Dutch kilns—These so-called Dutch kilns are a slight improvement over the scove kilns, since they have permanent side walls, and so heat up better, and admit less cold air. They are rectangular in shape and

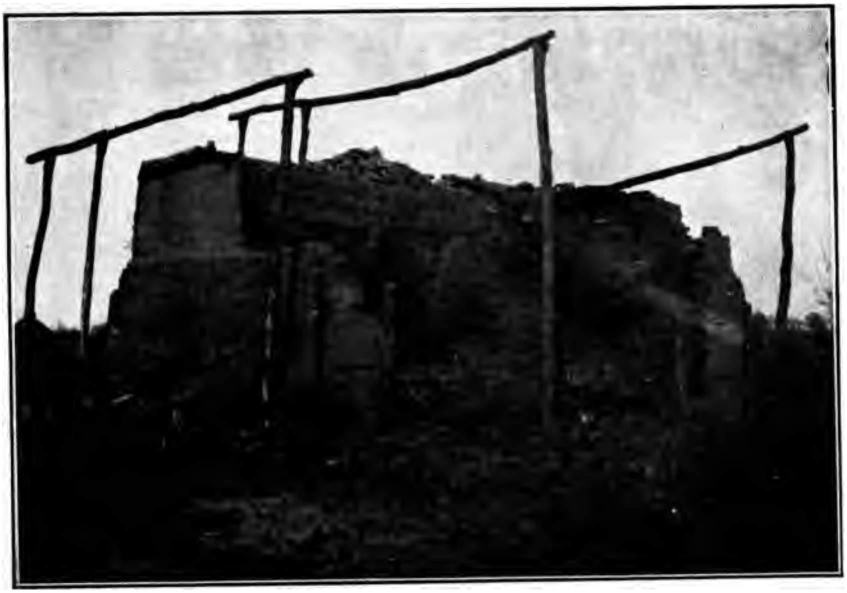


Fig. A. Scove Kiln, With Brick Largely Removed, Paris, Tennessee.

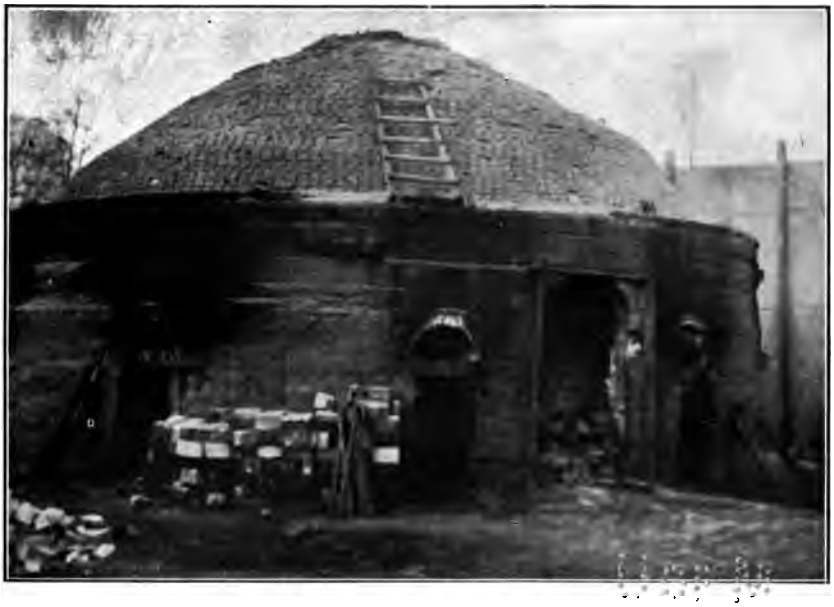


Fig. B. Typical Downdraft Beehive Kiln, Showing Finished Burn. Southern Tile and Brick Works, Gilmore, Tennessee.

OLD AND NEW METHODS OF BURNING BRICK.

the same size as the scove kiln. The walls are about 4 feet thick at the base, and the fire holes about 8 feet long. (See plate 5, Fig. B.)

Downdraft kilns—These kilns are completely walled in, and are so arranged that the heat is carried to the top of the kiln by inside flues, then going down throught the brick, escapes through holes in the floor. They are built either in the shape of a beehive or rectangle. The beehive kilns are about 25 feet in diameter and 8 feet to the beginning of the crown. The walls are 4 feet at the base and 2 feet at the top, and generally have 8 fire holes around the circumference at the base.

The rectangular ones are just like the Dutch kilns, except that they are roofed in, and have doors for charging and discharging.

Continuous kilns—The principal of this type is to utilize the waste heat from burning. It consists of a series of chambers arranged in a circle, connected with each other, and with a common stack by flues. To start, the first kiln is fired by means of exterior boxes, and while the smoke is coming off it is conducted to the stack, but as soon as this stage is passed, the heat is passed into the next chamber in succession. Thus the waste heat is utilized. When a compartment gets red hot slack coal is added through small openings in the roof, which are covered by iron caps.

It is possible in this kiln to be burning brick in one chamber while other ones are being heated up, filled and cooled.

Only one kiln of this type is in use in West Tennessee.

LABOR.

Where men are paid by the day the average is $1.25, with $2.00 for a few, who do special work. Many plants pay their men by the 1,000 brick, the following being the rate for West Tennessee:

Brick molder	$ .40
Mud wheelers	.21 to .25
Mud temperer	.22½
Off bearers	.16 2-3 to .20
Rackers	.21
Brick setters	.12½
Brick wheelers	.25 to .30

The labor required for making and burning the brick varies from about $1.25 up to about $2.90 a thousand. The average cost for labor is about $1.75 per thousand brick for either three classes of machines. The dry press machine requires less labor than the others if worked properly.

The cost of manufacturing brick in West Tennessee, leaving out wear on machinery, mining of clay and office expenses, varies from about $2.50 to $4.85 a 1,000, while the selling price varies from $5.50 to $12.00 a thousand.

BRICK OUTPUT FOR 1910.

There were between sixty-two and sixty-three million bricks made in West Tennessee during 1910. Twenty-five plants were visited at the following towns: (See Plate 6.)

Towns	No. of Brick Made	
Brownsville	850,000	
Bolivar	1,000,000	
Covington	1,000,000	
Cottage Grove	200,000	
Dyersburg	3,000,000	
Gilmore	4,000,000	
Humboldt	1,000,000	
Jackson	2,000,000	
Lexington	2,000,000	
Martin	2,500,000	
McKenzie	2,000,000	
Memphis	35,500,000	4 plants
Milan	2,000,000	
Obion	400,000	
Paris	400,000	3 plants
Ripley	1,600,000	
Rives	400,000	
Scott's Hill	150,000	
Trenton	600,000	
Union City	2,000,000	
Whiteville	250,000	
	61,050,000	

The towns of Middleton and Trezevant have plants, but they were not in operation in 1910, as there was no local demand for brick. In 1909, the plant at Middleton produced 200,000 brick, while at Trezevant 900,000 were made.

There are probably scattered through the counties a few other small scove kilns, which would increase the total production to nearly sixty-two million. The capacity of all the permanent kilns that are situated in West Tennessee is 18,321,000 brick. This does not include the scove kilns, which are used in seven plants. The downdraft kilns have 2,410,000 and the updraft 16,090,000 brick capacity.

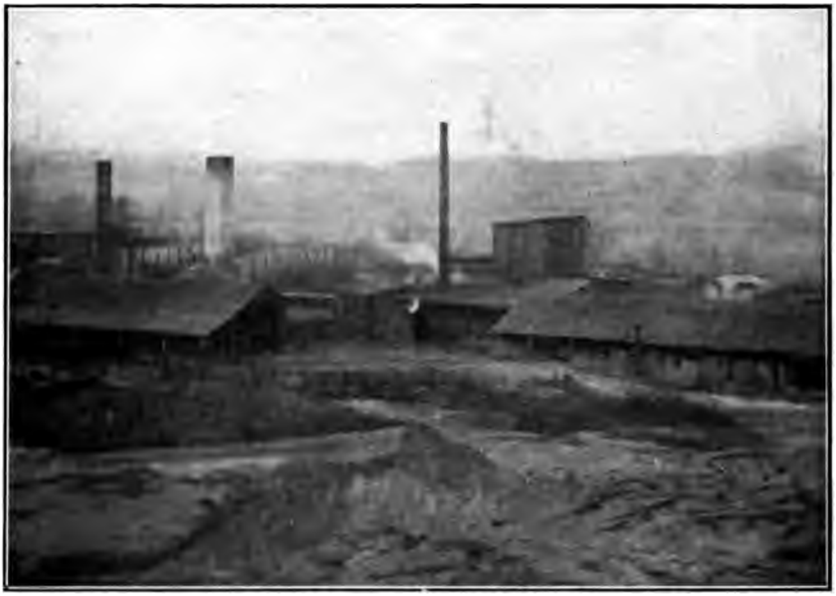


FIG. A. SOUTHERN TILE AND BRICK WORKS, GILMORE, TENNESSEE.
Showing kilns, sheds, powerhouse in background and part of pit in foreground.

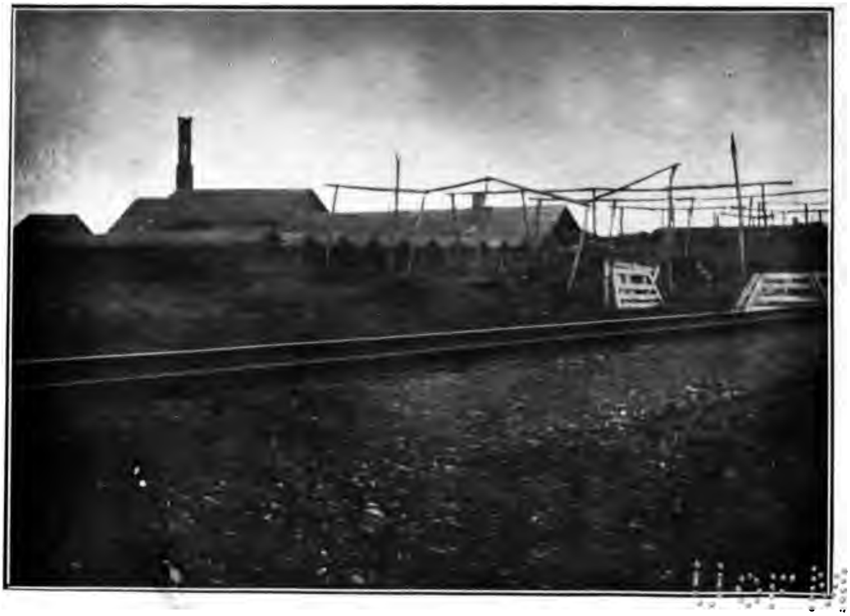


FIG. B. COSTEN-MOORE & COMPANY, McKENZIE, TENNESSEE.
Showing drying and machine sheds and Dutch kilns.

BRICK PLANTS OF WEST TENNESSEE.

CLAY OUTPUT FOR 1909.

The following tables were taken from State of Tennessee Mine Inspector's report for 1909:

Clay mined and sold in Tennessee in 1909. Short tons.

	No. of Employees	Ball	Fire	Sagger	Stoneware		Miscellaneous	Total
Hardeman ...	7				223			223
Henry	136	16,993	7,122	940	1,500	6,080	700	33,335
Madison	5		230					230
Weakley	1				15			15
	149	16,993	7,352	940	1,738	6,080	700	33,803

Products and Value.

	Product Short Tons	Value
Ball clay	16,993	$50,735
Fire clay	7,352	9,847
Sagger clay	940	1,640
Stoneware clay	1,738	2,000
Wad clay	6,080	7,460
Miscellaneous clay	700	1,250
	33,803	$72,932

SELLING PRICE OF BRICK AND CLAY.

The selling price of bricks vary, not on account of any great difference in cost of fuel and labor, but on account of lack of competition.

Bricks sell in the largest towns for from $6.00 for the run of kiln up to $16.00 for specials. In the smaller towns the prices are higher averaging $7.00 or $8.00 a 1,000 for common unpressed brick. In a few of the smaller towns the brick sell at as low as $6.00 a 1,000, while, when they are shipped the prices are cut to meet competition, and often they are sold at $5.50 f.o.b.

The ball clay shipped north brings for the best grade, prices ranging from $3.50 to $2.50 a ton, while sagger brings $1.50 and wad $1.25 a ton. All of these prices are f.o.b. shipping point.

SELLING PRICE AND OUTPUT OF STONEWARE FOR 1909.

There are four potteries in operation in West Tennessee at present, located at Grand Junction, McKenzie, Pinson and Toone.

The ware is made on potters wheels or in molds, and then after drying it is dipped in some kind of slip, and then put in beehive kilns and burnt. The burning occupies from 12 to 70 hours, and is done by coal or wood.

The following articles are made: flower pots, chicken founts, jars, churns, pitchers, sewer pipes, cuspidors, milk pans and chambers, in various sizes. In 1909 there were about 230,000 gallons of the foregoing ware made, which sold at from 5 to 7½ cents a gallon, f.o.b. the plant.

CLAY RESOURCES BY COUNTIES.

BENTON COUNTY.

Benton County lies along the Tennessee River in northeast part of West Tennessee. The rocks outcropping here are the old Paleozoic limestone, the Ripley sands, and in the extreme south a small area of the Eutaw formation. Of these formations the Ripley is the only one which is at present worked. No clay deposits are worked in it in this county, although outcrops of a white clay have been found north of Camden. No deposits were visited in this county.

CARROLL COUNTY.

Topography—Carroll County is situated in the northeastern part of West Tennessee. In shape it is nearly square, and has an area of 624 square miles.

The Tennessee divide crosses this county, making the drainage of the county run east and west; about one-third drains into the Tennessee River and Big Sandy, and the rest into the Mississippi. The surface on either side of the divide is very hilly, and many gullies are in evidence, as erosion is active along the divide. The streams in the northern and western part of the county have broad flood plains, and the country is more level. The elevation of the divide is from 450 to 500 feet, while along the river bottoms the altitude is about 375 feet. The average elevation is near 425 feet.

Railroads and towns—The county seat is Huntingdon, a prosperous town, situated in the center of the county on the Nashville, Chattanooga & St. Louis Railway. Its elevation is 414 feet. The only other important town is McKenzie, situated in the northwest corner, at the junction of the Nashville, Chattanooga & St. Louis, and Louisville & Nashville railroads. This place has an elevation of 481 feet, and is the largest town in the county.

The railroads cover the county very well, two junctions being situated in it, one at Hollow Rock Junction, where two branches of the Nashville, Chattanooga & St. Louis meet, and the other at McKenzie, where a branch of the Louisville & Nashville meets the main line of the Nashville, Chattanooga & St. Louis. The Nashville, Chattanooga & St. Louis crosses the northern and eastern parts of the county, while the Louisville & Nashville runs through the western portion.

Geology—The Selma clay covers a few square miles in the southeast corner. West of it, and along the eastern border of the county, is a belt of Ripley sand 6 to 8 miles wide. Next to this the Porter's Creek outcrops across the county in a belt 2 miles wide, its western edge passing through Huntingdon. This leaves the whole western half of the county underlaid by the LaGrange sands and clays. The whole county is overlaid by a thin blanket of Lafayette sands.

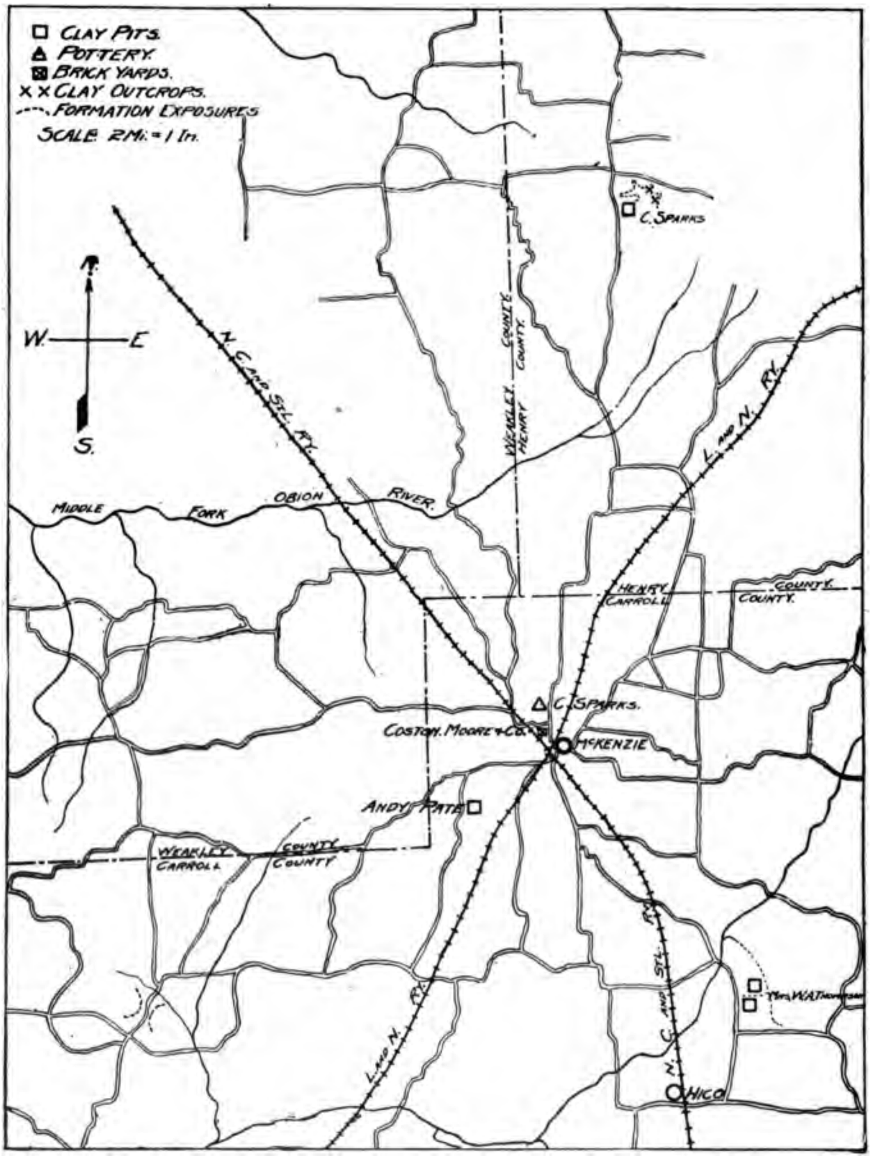
Clay deposits—Most of the clay mined is shipped to Nashville to be used in the making of pottery. There are four pits located along the Nashville, Chattanooga & St. Louis Ry., west of Hollow Rock, and one south of the town. They are all in a radius of 3 miles. At Hico, just west of Hollow Rock, there are some old pits from which clay was shipped several years ago, but are now abandoned. Clays are mined for the manufacture of brick at McKenzie and Trezevant. Deposits of fire clay occur south of Huntingdon and McKenzie, and west of Trezevant. Only the deposit at McKenzie has been worked, and that has been used only for a few local brick. There is also a pottery at McKenzie. East of Trezevant is a blossom of very plastic clay, which should be tested. All the deposits around Hollow Rock are in the Ripley formation, while the rest of the pits are in the LaGrange, with the exception of the Lafayette clays, which are used for brick at McKenzie and Trezevant.

Hico—The old pits from which clay was taken to ship to Louisville for pottery are located in a ravine just south of the Hico schoolhouse, which is 2 miles north of Hico on the road to McKenzie. (See map of McKenzie and vicinity, page 42.) Very little information could be gotten concerning these pits, as they have not been worked for three years. They are owned by Mrs. W. A. Thomas, of Hico. There is a natural outcrop of the clay along the south bank of the small stream along the bottom and up the sides of the banks for several feet. The deposit by the shed was worked by cutting away the side of the hill on the south side of the small stream, and draining into the nearby stream. The hill has been dug back about 20 feet for a distance along the stream of 150 feet. When visited the pit was nearly filled in, and all overgrown.

The best section obtained was the following:

	Feet
Light orange sandy clay, no gravel	6–15
Banded yellow and white sand	3–4
Clay lens, pinkish white, exposed to stream bottom	5

PLATE 7.



MAP OF CLAY OUTCROPS AT McKENZIE, CARROLL COUNTY, AND VICINITY.

Although only 5 feet of clay is exposed, the bed is several feet thicker, as the clay extends down under the stream bed. The clay is very plastic, and works well, but seems to have a small amount of grit present. It is slightly colored by the presence of a small amount of iron, which gives it a mottled pink and white color. The clay has a conchoidal fracture.

Small sand grains are scattered through the mass, as well as a small amount of organic matter, such as rootlets, etc. No concretions or boulders were found.

The clay in this pit is in the lower part of the LaGrange formation. Above it is a mantle of Lafayette sandy clay which rests unconformably upon it.

The outcrops occur at the foot of the hill, and extends all along the stream. The main stream runs east of the hill with a small stream already mentioned, which runs north of the deposit. This stream is fed by springs which come out of the clay lens. The hill extends southward from the outcrop. (See frontispiece.)

The overburden is a light sandy clay, which reaches in the center of the hill a thickness of about 30 feet. This maximum thickness of overburden is reached about 75 feet from the outcrop. The overburden is of a loose sandy nature which can be removed. The clay lens most probably also thickens in the center, so that the overburden may not be so much as it would seem from surface indications.

In regard to the accessibility of the deposit. It can be reached by a common dirt road, which crosses the Nashville, Chattanooga & St. Louis Railway inside of a mile, or the clay could be shipped from Hico, 2 miles distant. The entire hill is covered with timber, of fairly good quality, including oak, hickory and chestnut. No good supply of water is available at present, as the springs are small and weak, and the main stream west of the deposit is a dry bed most of the year. Any coal used would have to be shipped in by rail.

About 100 yards from the first pit, and nearer the Hico schoolhouse, on the east side of the road, is another old pit, identical in most respects with the other. Its section is as follows:

Section of pit near Hico schoolhouse.

	Feet
Lafayette:	
Light orange sandy clay	20
Banded white and orange sand	5
LaGrange:	
Clay white and pink to road bed	5

This pit has been excavated back 50 feet, and about 75 feet wide. The dry stream bed is just across the road from it, the road in places running through its bed. This pit also has filled in greatly, as it has not been worked for three years.

The following is a section of a gully at the Hico schoolhouse:

Section at Hico schoolhouse.

	Feet
Columbia:	
Light yellow	1
Lafayette:	
Dark orange case-hardened sandy clay	10
LaGrange:	
White and orage cross-bedded, case-hardened sandy clay	15

Hollow Rock—Bill Barnhart pit—The pit is situated 2 miles west of Hollow Rock on the north side of the Nashville, Chattanooga & St. Louis Railway. (See map of Hollow Rock and vicinity.) The pit is owned by Bill Barnhart, of Hollow Rock.

The clay outcrop at base of hill is a small "blossom." The pit is about 100 feet wide, and extends into the hill for nearly 100 yards, and the bed has a thickness of 7 feet. The clay extends back under the rest of the hill, which covered about 10 acres.

The following is a detailed section of pit:

Section at Barnhart pit, near Hollow Rock.

	Feet
A sand, dark red, hardened at top which grades to a lighter color, and finally into a yellow sand above the clay	20–25
Clay greyish yellow, slightly gritty, no nodules	7
Sand fine yellowish white, extends down under clay.	

The clay is colored grey by the presence of a slight amount of organic matter. Very little iron is present, only enough to give it a slight yellow tinge. The clay is of a fairly uniform color, which gets darker toward the bottom of the deposit. It has a conchoidal fracture. No analysis has been made of this clay. Leaf impressions are found in certain layers, and the whole bed is slightly gritty, but no nodules of iron or any other mineral are present. The bed is massive, without joints, or thin sand layers to break up, and clay breaks out in lumps of irregular size.

This clay as well as all the others around Hollow Rock is in the upper part of the Ripley formation. The overlying sands are of the Lafayette formation of the Pliocene age, and in all these pits forms the overburden.

This clay lies just at the base of the hill, where much water collects. This is removed by bailing, as the pits are only worked in dry weather. The overburden at the pit face is about 25 feet, and becomes heavier further back, the maximum being about 35 feet. The upper 15 feet

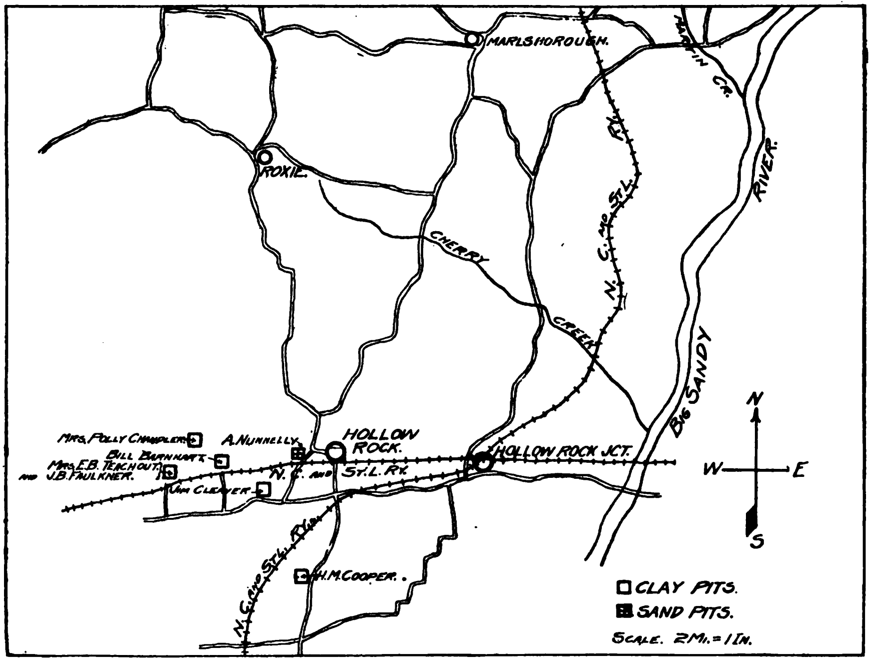


FIG. 3.
CLAY OUTCROPS AND DEVELOPMENTS NEAR HOLLOW ROCK, CARROLL COUNTY.

is very hard and difficult to remove, while lower down it is very easily removed, being a loose sand.

This pit is very accessible, as it is right on the Nashville, Chattanooga & St. Louis Railway, and only one-fourth mile from a switch where it can be loaded and shipped. The soil on top of the clay lens is covered with a light second growth of timber, most of it still small. The only water is gotten from wells, as the nearest stream is between 2 and 3 miles away. All coal is shipped from Kentucky or central and East Tennessee.

This deposit was opened ten years ago. It is worked by the open pit method, without machinery, and the clay hauled to the railroad in wagons. The area underlaid by clay has never been determined, but it is thought to underlie the whole hill. The hill extends 15 degrees west of north. The clay is used in the manufacture of pottery and stoneware, 400 tons being shipped last year to the Harley Pottery Company. Only one grade of clay is gotten here.

Mrs. E. B. Teachout and J. B. Falkner pit—This pit is located at the switch on the Nashville, Chattanooga and St. Louis Railway, 2 miles west of the town of Hollow Rock, on the north side of the track. It is owned at present by Mrs. E. B. Teachout and J. B. Falkner, of Hollow Rock.

The clay is 9 feet thick and is worked in open pit, 75 yards wide by 150 feet in depth.

Section of Teachout-Falkner pit, near Hollow Rock.

	Feet
Clay red sandy, case-hardened, clay pellets, and a sprinkling of gravel ..	20
Very light grey clay, nearly white	4
Changes to a black clay in the the lower part of the bed	5

The fracture is conchoidal, when broken, but generally splits into layers several inches in thickness, and is very plastic. The lower 5 feet contains a large amount of corbonaceous matter, which in places unfit it for use, also leaf impressions are sometimes found. The entire bed is slightly gritty, but no nodules of sand are present. The pit could be drained into a nearby gully. The overburden here is about 20 feet thick. The land is covered with only a few small scattered trees.

The pit is beside the Nashville, Chattanooga & St. Louis Railway, having a switch and sheds; no machinery is used. Only well water is available. Clay has been shipped from here for eight years to the Harley Pottery Company, at Nashville, Tenn. In 1910, 1,200 tons were shipped.

Mrs. Polly Chandler's pit—This pit is no longer mined, on account of the large amount of carbonaceous matter and iron present, which keeps the clay from burning white or cream. It is located one-half mile back from the Nashville, Chattanooga & St. Louis Railway at the Teachout switch. The overburden is from 15 to 20 feet thick. Many leaf impressions are reported found in this clay. Not visited.

Jim Cleaver pit—This pit is situated on the north side of the Huntingdon road, one mile from Hollow Rock. It is on the land of Mr. Jim Cleaver, of Hollow Rock.

The clay outcrops at the foot of a low hill for about 50 feet. It has been dug back for 30 or 40 feet, only a few cars having been shipped from here.

The following is a detailed section of the pit:

Section of Cleaver pit, near Hollow Rock.

	Feet
Hard red case-hardened sandstone, with small gravel scattered through it 1 inch in diameter and clay pellets	5
Light greyish yellow, with red iron streaks, and very sandy	5

The bed of clay, which is 5 feet thick, is very impure, and is only mined when the other pits are in an unworkable condition. Roots and stones are scattered through it, and in places streaks of iron are visible. No analysis has been made of this clay.

The clay is at the base of a low hill, with easy drainage. The overburden is from 5 to 8 feet thick, but hard, covered with second growth timber. Surface indications show about three acres of clay.

The clay is hauled by wagon to Hollow Rock for shipment. Only one car was shipped in 1909, that being sent to the Harley Pottery Company, at Nashville, Tenn. This pit was opened up several years ago and worked intermittently since then, when the other pits were filled with water.

H. M. Cooper pit—This pit is very small, but has a better grade than the preceding pit. It is on the road two miles south of Hollow Rock, though not as high grade as the Teachout clay, on the land of Mr. H. M. Cooper, of Hollow Rock. Several carloads have been shipped to Nashville.

The clay is in the Ripley formation, and has a slight overburden of Lafayette. It is mined by picks, and hauled by wagon to Hollow Rock. Not working at present.

Sands at Hollow Rock—Mr. A. Nunnelly, of Hollow Rock, ships molding sand, as well as sand for concrete and mortar purposes. This sand lies about 200 yards west of town on the north side of the Nashville, Chattanooga & St. Louis Railway. It is overlaid by about 2 feet of soil. The sand is of a brownish yellow color, but on drying becomes very much whiter.

Huntingdon—elevation 414—Several "blossoms" of good fire clay were found around Huntingdon, though none has been mined.

Six miles south of town on the Jenkins place the following exposure was found in a gulley:

Section 6 miles south of Huntingdon.

	Feet	Inches
Lafayette:		
Orange sand, loose and incoherent with very little gravel, several streaks of broken ironstone hard pans are scattered through the bed	12	
Iron sand hard pan		6–12
LaGrange:		
Sand, cross-bedded, case-hardened, micaceous of orange color, banded in light and dark layers	8	
Clay, white sandy, which is hard and does not slack easily, but forms icicles of clay, where water has run over it	5	

This deposit has too much overburden, and is too inaccessible to be of present use.

The following is a road cross section of the surface sands and gravels taken from the Purdy road 1 mile south of Huntingdon:

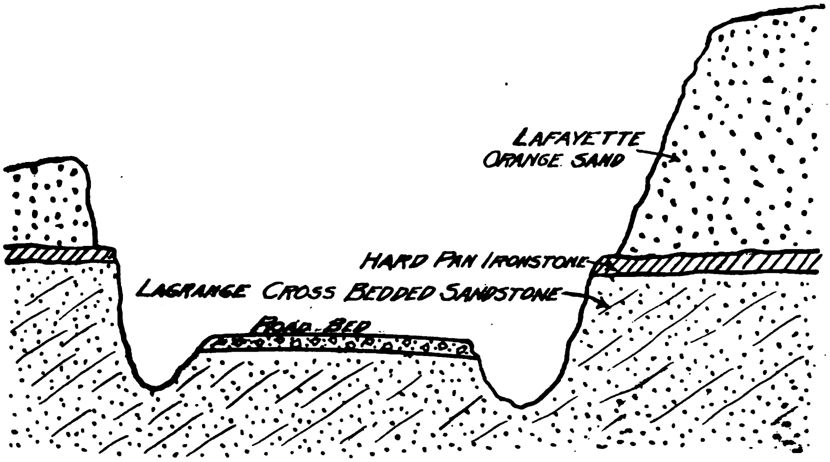


FIG. 4 CROSS SECTION OF ROAD SHOWING SURFACE FORMATION SOUTH OF HUNTINGDON

The Purdy road, after it turns south, has outcrops of Porter's Creek clays in the road cuts for 2½ miles. These are overlaid by Lafayette sands or clays, in many places only a foot or so thick.

About 3 miles from Huntingdon, on the same road, there is a deep road exposure, which does not show the Porter's Creek formation. The following is a section taken there:

Section 3 miles from Huntingdon.	Feet
Light orange sandy clay, no gravel hardened toward the bottom	12
White sandy clay	1
Hard sandstones cross-bedded to base of gully	5

Still following the road, we get for the next 3 miles the Lafayette sands, on the surface, with an iron hard pan at their base, and then a band of hard cross-bedded sandstone. In some places in this lower bed is found a white sandy clay interbedded with sand streaks. Lower down this grades into a yellow and white banded sand, which finally changes into a sandy clay. This is generally the mode of occurrence of the beds in this region.

At Huntingdon the following log of the deep well as given from memory by Mr. Dill, the engineer in charge of the waterworks. Well is 213 feet deep:

Record of well at Huntingdon.

	Feet
Lafayette:	
Yellow sand	15
LaGrange:	
Hard red sandstone	10
Porter's Creek:	
Hard dark grey clay	45–55
Very fine sand with mica	25
Layers of grey clay and fine sand, each layer not more than 1½ inch	60–75
Ripley:	
Lignitic material	6
Dark red loose sand	25

On the road leading west of Huntingdon, about 3 miles out, in a deep gully, an orange sand is found, which is streaked with bands of white sandy clay. The sand is cross-bedded. Thickness of whole exposure is 40 feet, but the clay bands are so small that the clay can not be used commercially.

About 4 miles out, the following section was taken:

Section 4 miles from Huntingdon.

	Feet
Light orange sandy clay with a small amount of gravel at the base, top 4 feet cemented into small iron pellets	12
White sandy clay, with pink streaks	3
Ironstone hard pan	3½
Dark orange cross-bedded sands streaks of light and then dark	15

The unconformity between the Lafayette and LaGrange formations seems to be at the top of the clay.

Two miles out on the road west of Huntingdon is an exposure of a white sandy clay, which is dark brown in one place. Indications are that this clay will get better under the hill, and a fairly good potters clay might be obtained. The clay is overlaid by 12 feet of red sandy clay, free from gravel.

At present no clay industry of any kind is located at Huntingdon. No clay outcrops of much value were seen, but from the formations here present, prospecting west of town might result in good ball clay being discovered.

McKenzie—There is located on the northern edge of the town a pottery operated by Mr. C. Sparks. (See Plate 7.) The clay is ground in a pug mill, worked by horse power; two-thirds of the mixture coming from the pit, and one-third being a sandy clay gotten nearby. The pit is located 6 miles north of McKenzie in Henry County. (For description, see page 97-A.) In winter the pottery is dried three days in the drying room, while in summer it is placed out doors to dry. The drying room has in it two long furnaces, 2 feet high and running nearly the length of the room. The jars are placed on top of these flues running back from the furnaces and on racks placed around the room. After drying, the ware is glazed by dipping in Albany slip, or for a white glaze a mixture of spar, whiting and ground flint. Zinc, too, is used with good results. Shrinkage of the clay is very slight, being 1 inch for every foot. The amount of clay used in a ten-gallon jug is 40 pounds, but after burning it has a weight of twenty-eight to thirty pounds. The finished ware is stored out in the yard without any cover.

The following products are made: Flower pots, 4 to 12 inches in diameter; chicken founts, one and two gallons; jars, one to ten gallons, and churns, one to ten gallons. About 1,000 fire bricks are made yearly for local use.

Two potters wheels run by foot power are used in molding the ware. They have no plaster of paris casts. The clay is tempered by cutting again and again against a fine wire stretched tight over a board. In this manner it is well mixed.

The burning is accomplished in one down draft kiln of 25,000 gallons capacity. Its diameter is 12 feet, with a height to the beginning of the crown of 6 feet There are four fire grates. Coal from the Reniecke Coal Mining Company at Madisonville, Ky., is used in burning the ware. The actual burning takes about seventy hours; taking into account the setting and cooling, only two burns are made a month.

The pottery is shipped as far east as Dickson and north to Hickman, while south they are shipped to within 25 miles of Memphis. The rates are fairly good, but those on the Louisville & Nashville Railroad are slightly higher than on the Nashville, Chattanooga & St. Louis Railway.

Costen, Moore & Co.—The brickyard and its pit is located on the north side of the Nashville, Chattanooga & St. Louis Railway, about a fourth of a mile east of the depot. The property is owned by Costen, Moore & Co., of McKenzie. (See plate 6, Fig. B.)

The clay is mined from a pit just across the road from the brickyard. The surface clays are used down to 8 feet, the upper foot or two being Columbia loess, the rest Lafayette clay—of a light orange color. The clay has been mined over about two or three acres down from 3 to 8 feet.

The deposit is of a light orange sandy clay, very loose, and soft. No boulders or beds of gravel are found mixed with the clay, but after a depth of 8 feet has been reached the clay becomes too tough to be used in brick manufacture. This toughness seems to be due to the amount of iron present in the lower layer, while in the upper deposits it is lacking, as the iron has been leached out by the action of the percolating waters. The clay has enough plasticity to permit of being molded when wet if under pressure. The clay is mixed with a great deal of sand, and the grains can be readily seen.

Nothing has to be removed in mining this clay, as it is used from the surface down. The supply of this clay is inexhaustible, as the whole region is covered with it. Water is gotten from bored wells.

A company has been in operation at this place for twenty-one years. The clay is mined by picks, shovels, and horse scrapers, and is carried over to the mixer, a pug mill, Monarch make, which is run by steam. The bricks are made by the soft mud process, the molders being sanded instead of oiled. The bricks are dried on racks in the open air, the racks each having a little roof over them to keep off the rain. They have here a shed capacity of nearly 200,000. The bricks are dried from four days to a week, according to the weather conditions. After drying the bricks are carried by wheelbarrows into the kilns and there set. No work is done in the winter months, as the bricks are apt to freeze and become ruined. No shrinkage tests have been made of the bricks either in drying or burning, as it is very slight.

Only soft mud bricks are made, though at one time a repress brick was made, but this was stopped as they cracked and scaled.

There are four updraft kilns of 170,000 capacity each. Coal is used in burning, and about eight days are taken for drying and burning. The kilns have eleven fire holes or "eyes" on the two long sides.

The capacity for the last year was 2,000,000 brick, the daily capacity being 20,000. The plant capacity is to be enlarged this winter. The rates on both railroads are fairly good, and bricks are shipped into a territory of about 50 to 75 miles radius.

The Louisville & Nashville Railroad has just put down a well 647 feet deep at McKenzie. The following is the section as gotten from M. P. Walden, Superintendent of Water Supply of the Louisville & Nashville Railroad:

Section of well at McKenzie

	Feet
Soil, loam and clay	10
Sand, red	26
Sand, white	11
Sand, red (water struck)	20
Sand, fine white	34
Sand, white, and pipe clay mixed	50
Pipe clay, grey	74
Pipe clay, dark	38
Sand, yellow	10
Sand, white	38
Sand, white, coarser	9
Pipe clay	8
Sand, fine, white	2
Pipe clay	2
Sand, fine, white	16
Pipe clay, grey	122
Pipe clay, dark	47
Sand, fine white	6
Pipe clay, dark or soapstone	20
Sand, white, fine	35
Sand, white, coarse	52
	647

A good water supply was here struck.

Fire clay pit—There is a small pit located two miles southwest of McKenzie, on Andy Pate's (col.) farm, which has been worked by Costen, Moore & Co. and C. Sparks, for fire brick clay to make the bricks for their kilns.

This clay is located on the side of a low hill, and is covered by an overburden of several feet of light orange sandy clay. The clay used for fire brick is a sandy white clay, streaked with iron stains, and in places nodules and gravel are scattered through the bed. The clay from indications covers three or four acres, and in no place should it have an overburden of more than 5 feet. The drainage is good. About one or two carloads of clay have been mined. None has been shipped out of McKenzie; it has all been used locally. The clay is too poor to be shipped, as much better fire clays are found elsewhere and directly on the railroad.

Trezevant brickyards—Brick are manufactured here by Mr. O. C. Sloan, of Trezevant. This yard is on the northeast edge of town, about 100 yards from the railroad.

The clay used here is taken from the surface. It is a light orange or red sandy clay of the Lafayette formation. It is used down to about 4 feet, below that depth it is too rough for brick making. The clay is mined from the side of the brickyard. An Eagle soft mud brick machine is used, which is run by a Huber engine of about ten-horse power. It has a capacity of 18,000 bricks daily. The bricks are dried in open air racks. Bricks are all of soft mud type and are burned in two updraft kilns (Dutch kilns) of 175,000 capacity each. Cord wood fuel is used, and about eight days are required for drying and burning.

No bricks have been made since 1909, when 900,000 bricks were made. No bricks were shipped away, they all being used locally in brick buildings.

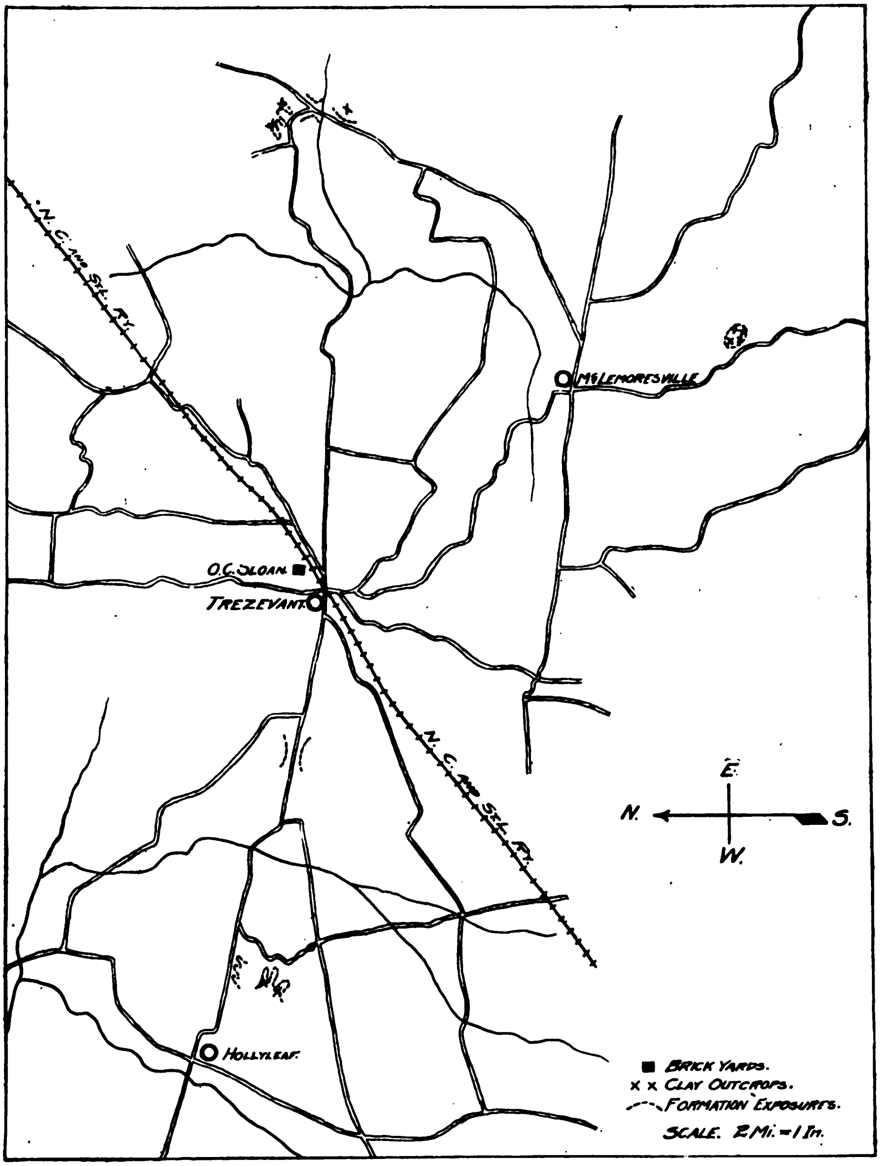
On the Trezevant-Hollowleaf road—Four miles out from Trezevant, on the south side of the road, are some gullies, which contain the following section:

Section 4 miles from Trezevant.

	Feet	Inches
Yellow streaked sandy clay	5	
Iron pan		1
White sandy clay	10	

A sample of this lower bed of clay was tested, and burnt to a light cream color at the temperature of cone 11, with an air shrinkage of 6 per cent, and fire shrinkage 8.5 per cent. Its appearance suggests its use for fire brick. It is not plastic enough for a ball clay, even if the sand could be washed out.

PLATE 8.



MAP OF CLAY OUTCROPS AT TREZEVANT AND VICINITY, CARROLL COUNTY.

Just south of the preceding, a very plastic, light pink clay, free from grit is exposed in a number of gullies to the west of the road to William Watkins' place. In the gully farthest south just before the road goes down the hill, the following section was viewed:

Section near Trezevant.

	Feet
Lafayette:	
Light orange sandy clay, no gravel	6
LaGrange:	
Darker orange case-hardened, cross-bedded sand, very little clay	5–7
A very good white clay, exposed to bottom gully	12

In another gully 100 yards north of the former and back from the road, another good exposure was found, as follows:

Section west of Trezevant.

	Feet
Lafayette:	
Clay, light orange sandy	5
LaGrange:	
Sand clay, cross-bedded, dark orange, case-hardened whitish clay pellets scattered through it	12
Clay, white, exposed to bottom of gully	3

The lower bed of white clay, of which only the top is exposed, is one of the best plastic clays, which was found outside of Henry County. This clay undoubtedly extends down at least 4 or 5 feet below the bottom of the gully, and should change into a better quality. In places a slight pink mottling is visible, but there is not an injurious amount of iron present. The clay has a fine conchoidal fracture. There is no grit or sand present, and no concretions or nodules of any kind were found.

This clay lens lies in the middle part of the LaGrange formation. The unconformity between that bed and the Lafayette lies between the soft light orange sandy clay, and the hard cross-bedded dark orange sand, which overlay the clay. The clay appears to extend northward from the exposure, and probably covers only 3 or 4 acres.

Outcrops can be found in most of the gullies around this locality on all sides of the hills, which will aid materially in determining the extent of the clay lenses. Any pit here could be easily drained.

The overburden, which will vary from 17 feet at the outcrop to about 25 feet under the hill, is at the top a loose sandy clay, easily removed. Below this is a bed of sand, case-hardened, which could be removed without much difficulty. This outcrop is 4 miles by road to Trezevant and 2¾ miles by nearest road to the railroad, 4 miles south of Trezevant.

No clay has been dug at this point, and no other good exposures were seen, but prospecting done in this locality would undoubtedly uncover some good ball clay deposits. On the Hollowleaf-Trezevant road 1½ miles from Trezevant, a road exposure of a light yellow, sandy clay was found on a steep hillside. This clay is nearly white, and probably would become free from grit if the lens should be worked back.

Newbill Crossroads—On Mr. Ed Parnell's farm, 4½ miles out, are several gullies, on the northeast side of the road. The following is a section of them:

Section at Newbill Crossroads.

	Feet
Clay, mottled light yellow or white, sandy	15
Clay, banded layer of light orange and white, sandy	12

No good clay was found in this gully. In a second gully 50 yards from the first, this section was seen:

Section at Newbill Crossroads.

	Feet
Clay, light orange, sandy, case-hardened in places and white clay pellets scattered through it	15
Clay, yellow, no sand, exposed at base of gully on left side coming up to its head	½

This clay is very plastic and free from grit. It has too much iron in it to be used for ball clay, but should make a good sagger clay. No determination was made of the depth of this bed. The hill that has the gully in it is of ten or twelve acres in extent, but in its highest part has an oberburden of 35 or 40 feet, which is prohibitive. Taken all in all this deposit could not be worked economically.

About one mile beyond this an exposure of the surface formations is seen, where the road goes down Baxter Hill. The following is a sketch of it:

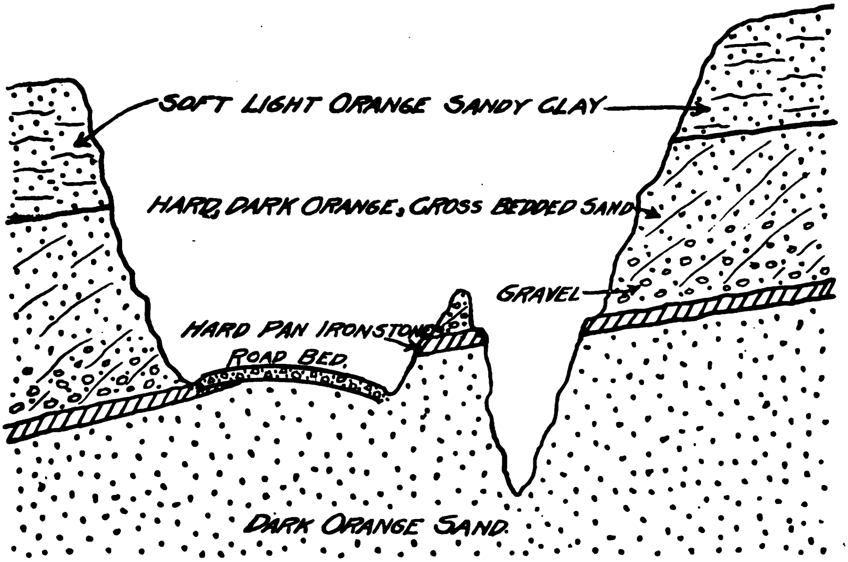

SOFT LIGHT ORANGE SANDY CLAY
HARD DARK ORANGE, CROSS BEDDED SAND
GRAVEL
HARD PAN IRONSTONE
ROAD BED
DARK ORANGE SAND

FIG. 5. Cross Section of Road Showing Surface Formation on Baxter Hill, 5 Miles East of Trezevent.

One hundred yards further down the hill a small white sandy clay streak appears on the road cut. It is of no value.

On the road leading south of McLemoresville, 2 miles out, there has been about an acre washed away, leaving exposed the following section:

Section south of McLemoresville.

Section on the west side:	Feet
Clay, light orange sandy	4
Sand, dark orange, with clay pellets, case-hardened, and cross-bedded with soft iron concretions at the base	4
Clay, white sandy	10

This clay might make a fire brick, judging from its appearance, but it is about 6 miles from the nearest shipping point at Trezevant on the Louisville & Nashville Railroad.

On the road from McLemoresville to Trezevant, 1½ miles from Trezevant, on Capt. Bohannon's place, which is on the north side of the road, a dark grey molding sand is gotten at the base of the hill. This is covered by about 25 feet of overburden in the center of the hill, but none on the side where they are now mining it. This sand is made use of in the foundry at Trezevant by Hurdle Brothers.

CHESTER COUNTY.

Topography—This county is very irregular in shape, and is situated in the southeastern part of West Tennessee. Its area is 300 square miles, most of which is drained into the Mississippi River. The Mississippi-Tennessee Divide runs through this county, and has a height of 600 feet in places. Along this divide the surface is very hilly and rough. Both the slopes are cut up, on the west by the headquarters of the Forked Deer, and on the east by small streams tributary to the Tennessee River. The middle and western part of the county are more level, the stream valleys being about 30 feet lower than the surrounding country, which is fairly level. The average elevation is 450 to 500 feet.

Railroads and towns—The Mobile & Ohio runs north and south through the center of the county, passing through Henderson, the county seat. This is the only town of any importance in the county.

Geology—The rocks consist of the Selma clay, and Ripley formation of the Cretaceous, the Porter's Creek and LaGrange of the Eocene and the Lafayette of the Pliocene. The east end of the county is underlaid by the Selma clay. In the central part of the county is the outcrop of the Ripley sands and clays, Henderson being on its western edge. West of the Ripley formation the Porter's Creek extends across the county in a band 4 or 5 miles wide. The overlying Lafayette has been removed from it in most places. In the extreme western part of the county the LaGrange sands outcrop over an area 3 or 4 miles wide, drained by the Hatchie River.

Clay—No white clay was heard of in this county. The only place visited was Henderson, and no information could be obtained there relative to any white clay in the neighborhood.

If any clay is to be found, it should be looked for east or south of Henderson in the Ripley formation, where clay lenses are sometimes found; or in the extreme western edge of the county, in the LaGrange sands and clays, which are here several miles from the Illinois Central Railroad.

CROCKETT COUNTY.

Topography—This county lies between the middle and south fork of Forked Deer River, having an area of 267 square miles. The divide between these 2 branches of the river runs in a northwest and southeast direction. The central portion of the county is a gently rolling to level upland, with an elevation of 400 to 425 feet. Near the eastern and northwestern parts of the county the land is hilly on account of the nearness to the large streams. Along these rivers the elevation is lowest, being about 300 feet.

Railroads and towns—The Louisville & Nashville Railroad crosses the southeastern edge. The county seat, Alamo, is off the railroad. A new road is being promoted, which is to run from Dyersburg to Jackson, passing through Alamo and several other towns. This road, if carried through, will open up the county greatly.

Geology—The LaGrange underlies the whole county and is covered by a mantle of Lafayette, but in the northwest end the covering is of Columbia loess and loam several feet thick.

Clays—In the southeastern part of the county along the Louisville & Nashville Railroad, there are deposits of light colored sandy clays, which might be utilized. Clays found elsewhere lack transportation facilities. Dr. L. C. Glenn, in his paper on the underground waters of West Tennessee and Kentucky, mentions lignitic clays being found in the northwestern part of the county. These clays when dried have in places enough lignitic material in them to permit of burning. A clay like this would be of no use economically to clay manufacturers. This territory was not visited.

DECATUR COUNTY.

Topography—This county lies just west of the Tennessee River, and is drained entirely by that river. The highest elevation is 600 feet on the ridges, while along the streams the altitude is about 400 feet.

Railroads and towns—A branch line of the Nashville, Chattanooga & St. Louis Railroad runs across the center of the county, from west to east, having its terminal at Perryville on the Tennessee River. Decaturville, the county seat, is 5 miles south of the rairoad, and is reached by a pike running from Parsons on the railroad.

Geology—Over half of the county is covered by the old Paleozoic limestones, while the rest of the county on the west is covered with the Eutaw sands of Cretaceous age, which were laid down on the old Gulf embayment. The limestone here is of Silurian age and is covered by a blue clay formed from the disintegration of said rocks. In places the limestone is overlain by deposits of Camden chert of Devonian age.

Clays—Just north of Perryville on the river are several pits where the Camden chert was worked. The chert goes to a depth of 40 to 60 feet to the limestones. This Camden chert is really a variety of novaculite, and has been used with very fine results as road metal. At present no novaculite is mined, as all the most available pockets have been worked out, and now all the quarries are in the limestone. This is being mined and crushed by the Memphis Stone & Gravel Company, Mr. R. H. Carney, in charge.

Just east of Parsons on the Nashville, Chattanooga & St. Louis Railroad, the Memphis Stone & Gravel Company have several other pits located that are worked for gravel. These pits were not being operated when visited.

No clays are used in this county at present, but there are surface clays over the limestone, and also clays in the Eutaw sands, which could be utilized for making common brick. (See introduction, p. 9, for clays at Parsons.)

DYER COUNTY.

Topography—This county is situated in the northwestern part of this area. It is bounded on the west by the Mississippi River, and on the south by the Forked Deer River, and its south fork. It has an area of 500 square miles. The eastern part of the county is characterized by hilly uplands, while the western portion is the alluvial flood plain of the Mississippi, Obion and Forked Deer rivers. These bottoms are 225 to 250 feet above sea level, while the uplands have an elevation of about 375 feet.

Railroads and towns—The Illinois Central Railroad enters the county in the southwest and traverses it, going out in the northeast corner. The Chicago, Memphis & Gulf Railroad goes from Dyersburg, the county seat, to Tiptonville, on the Mississippi River. Dyersburg is the largest and most important town in the county.

Geology—The formations which are on and near the surface here are the LaGrange, the Lafayette, the Columbia loess and the Alluvium.

Of these deposits only the Lafayette and loess are used in brick making. The LaGrange is too deep in most places, being laid bare only in a few of the deepest ravines. In most places only the loess is used, and it is about 30 feet thick on the Illinois Central Railroad. On the eastern edge of the county it thins out to a few feet.

Clays—No clay is used in this county, except for making common brick and drain tile, the latter being made at the brick yards, as no separate plants are in existence.

Dyersburg—A brick plant is located here, which is owned and operated by Mr. J. M. Nichols of this place. The pit is located by the side of the plant, and clay has been used down to 10 feet at which depth it becomes too tough to be used. This clay is a loose, unconsolidated loess, which is easily dug by pick and shovel. No stripping is required, as it can be used from the surface down.

The quantity of material is unlimited, and in no place is any overburden to be removed. The dark to black loess, which is used in making the tiles, is found on the southwest edge of town. This deposit varies with the light loess, as a surface deposit, and is in nearly as great abundance.

The plant has been in operation for many years, but no brick has been made for two years. A soft or stiff mud brick can be manufactured. A Quaker soft mud machine, with a daily capacity of 20,000, is used; also a Brewer machine, which is used for making the stiff mud brick. This latter machine can also be used for making tile. Its daily capacity in brick is 20,000, or in 5-inch tile it is 4,000.

One downdraft rectangular kiln of 300,000 capacity is used. The brick take two weeks to dry and burn. Wood is used in drying out, a half cord being allowed to the 1,000 bricks, while coal is used in the burning.

This plant has made few bricks since the Tennessee Brick & Tile Company opened up a plant here five years ago.

Tennessee Brick & Tile Company—This plant is located on the east side o fthe Illinois Central Railroad on the north edge of town. Mr. L. L. Lovin is manager.

The surface clays only are used at this plant. The clay to date has been dug to a depth of only 3 or 4 feet. The pit is located on the north side of the yard, and covers about one acre.

This plant has been in operation since 1905. The clay is dug by pick and carried by scrapers to the sheds, where it is stored for winter use. The clay becomes better on storing, as weathering helps it. It is taken from the sheds and carried by wheelbarrow to the disintegrator, where it is ground up. From here a canvas tude carries the ground clay to the dry press machine. The machine is a AA-118, Anderson Brick Press, made by the Scott Manufacturing Company, Keokuk, Iowa. It has a daily capacity of 20,000. The dry clay is pressed into the molds from above, at the same time the bottom of the mold comes up slightly, giving a better compression. The die has one or two air holes in it to permit the escape of any included air, which would cause blisters in the brick. The dies are steam heated.

The brick are wheeled directly from the dry press machine into the kiln where they are stacked for burning. No sheds are employed for drying the bricks. The kilns are downdraft of beehive construction and eight in number. Three of the kilns have a capacity of 7,200 each, the other five holding 60,000 each. Each kiln has four chimneys and eight fireholes. Wood is used to dry out the bricks and coal to burn them. The complete process takes twelve or fourteen days.

In 1910, 3,000,000 brick were made, all dark red, pressed brick. They sell at from $8 for kiln run to $15 a 1,000 for selected brick. With good railroad rates the bricks are shipped in a radius of about 50 miles.

No other brick are manufactured in this county, nor articles of any kind which utilize clay.

FAYETTE COUNTY.

Topography—This county is in the southwestern part of West Tennessee, and is bordered on the south by the State of Mississippi. It has an area of 618 square miles. The greater part is hilly and rolling. It all drains into the Mississippi River through its tributaries, the Hatchie, Loosahatchie and Wolf rivers. The surface is very hilly in the southeast part around LaGrange, which is 531 feet above sea level. This region is the highest part of the county. The lowest is about 250 feet in the northwest part.

Railroads and towns—Four railroads enter the county, the Nashville, Chattanooga & St. Louis, which traverses it from east to west in the central part; the Southern, which runs along the southern border; in the central part, the Southern, which runs along the southern border; the Louisville & Nashville, which crosses the northwest corner, and the Illinois Central, which crosses the southeast corner.

Somerville, on the Nashville, Chattanooga & St. Louis Railroad, in the center of the county, is the county seat, and principal town. Moscow and LaGrange, on the Southern Railroad, are of importance.

Geology—The LaGrange underlies all of the county, being exposed in deep gullies in many places, notably around the town of LaGrange, from which the deposit takes its name. (See page 15.) The surface is covered by 10 to 20 feet of Lafayette sands, and a few feet of Columbia sand or loam, the loess appearing only in the extreme northwest corner.

Clay deposits—Lenses of potters and fire (?) clay are found in the LaGrange formation in the southeastern part of the county. The potters clay is found along the Southern Railroad, west of Grand Junction, and fire (?) clay is found at LaGrange and east of Moscow on the same road. The only brick plant is located at Somerville and utilizes the Lafayette clay.

LaGrange—Clay was formerly shipped from here to Memphis by Mr. Jim Davenport, who lives a quarter of a mile west of town. The following is a section of the pit at his place.

Section at Davenport place, LaGrange.	**Feet**	**Inches**
Columbia formation	1–4	
Lafayette:		
A dark orange sandy clay case-hardened	2–4	
LaGrange:		
Clay, white plastic, with yellow streaks slightly sandy	6–8	
Clay, Ochre color, very plastic little grit present	4–6	
Hard pan		½
Sand at bottom of gully.		

This lower bed of clay was used by the old Memphis pottery, which has now gone out of existence. The clay has an overburden of about 15 feet at the face, with a maximum of 25 feet in the center of the hill. If the sandy white clay could be utilized for fire brick, or otherwise, it would be so much gain as it would have to be removed any way. The clay has been worked about 150 feet, but if persistent, would cover five or ten acres. This deposit is located at the head of a deep ravine, which drains the pit.

Mr. Davenport ships a great amount of sand to Chattanooga and Memphis from a gully south of town, on the P. R. Beasley land. The sand is dug from an open pit and brings from $1.25 to $1.75 a cubic yard.

Mr. McNanee ships sand from the bottom of a short gully next to P. R. Beasley's land. He uses a small engine to haul the sand up to the top of the gully. Most of this sand is shipped to Memphis, bringing $1.25 to $1.75 a cubic yard.

West of town a half mile is a large pit operated by Mr. Jeff Dale, which is reached by a narrow gauge road. This sand is shipped to

Chattanooga. The sand is brought up an inclined tramway in tram cars worked by a steam hoist, and dumped into railroad cars. This gully is over 100 feet deep, and has the following section:

Section of Dale sand pit, LaGrange.	Feet
Light yellow sandy clay	1
Red sand, loose, with an iron hardpan at the base	8–10
Old brown sandy soil layer	2–3
Sands, loose, uncemented, light in color, with orange bands in places, and streaks of pink and purple, in places cross-beded	60–90

About three-fourths of a mile west of Grand Junction on the north side of the Southern railroad are the clay pits of W. T. Follis. (See sketch No. 11.) The clay is used by Mr. Follis in his pottery at Grand Junction. It outcrops in the bottom of a nearby railroad cut, and also in several small gullies. It is mined in pits about 15 feet square, dug straight down, about 40 feet. Several pits have been worked out. As soon as this occurs another pit is started a few feet away. The following is the general section of the pits:

Section in Follis clay pits, Grand Junction.	Feet
Clay, dark orange red, at the base a gravel bed, composed or quartzite not more than 3 or 4 inches in diameter	3–12
Clay, pink and bally at top and breaks into little lumps	6–8
Clay in bluish bands, with fine white sand partings	20–30

The clay from these small pits is sandy, and colored by the presence of a small amount of iron, which gives the clay a yellow or light pink color. It has a rough texture, breaks into layers, and does not slack readily. No gravel is found in the clay, but it is gritty to the touch.

These clay lenses all occur in the lower part of the LaGrange formation, of Eocene age. They are elliptical and take a direction about twenty degrees east of north, and seem here to be about eight acres in extent.

Conditions affecting development--These pits are drained by bailing. They are not worked in the winter. The overburden in the pit worked is about 5 feet; further back on the hill it increases to about 10 or 15 feet. It is soft and loose and can easily be removed by pick and shovel. The clay is lifted out of the pit by buckets or a windlass and hauled by wagon to the pottery at Grand Junction. This pit was formerly owned by Mr. J. H. Prewitt of Grand Junction, who shipped clay to New Orleans and other points. It has been worked for about eight years.

For a report of the pottery at Grand Junction, see page 77.

The Handcock pits are located on the Illinois Central Railroad, about 1 mile south of Grand Junction, principally on the east side of the railroad, in Fayette County. The clay is overlaid by 4 to 6 feet of orange red sand, case-hardened, with a sprinkling of quartzite pebbles, up to one-half inch in diameter. The clay is a solid bed, very fine grained and sandy. It has a delicate pink color in places, but is mostly white on the outside, while on fresh exposure it is a light grey. Many beautiful leaf impressions were found in this clay, which had a beautiful pink tinge from the iron present.

This clay has been tried at Grand Junction Pottery, with poor results, as it checks, and does not hold the glaze. It has not been mined for several years.

Moscow—On Mr. Ike Chase's land, 2 miles from town, the following exposure was found in one of the numerous gullies:

Section on Chnse land, Moscow.

	Feet
Columbia formation	3-8
Lafayette:	
A case-hardened sandy clay, dark orange with small gravel and clay pellets scattered through it	6-10
Unconformity—	
LaGrange:	Feet
At top a band of clay pellets, further down are clay streaks, with a sandy clay lens at the base to ravine bottom	6

Further on, where the Southern Railroad runs through Mr. Chase's land, 2 miles east of town, by railroad, another section was taken in the railroad cut, which is as follows:

Section in railroad cut 2 miles east of Moscow.

Columbia foramtion	2-6
Lafayette:	
Light orange sandy clay, soft and loose, no gravel	0-3
LaGrange:	
In the center of the cut is the clay lens coming up in contact with overlying Columbia sands, while on the sides the clay lens is covered by several feet of LaGrange sands, dark orange in color. Total thickness of LaGrange to railroad track	10-15

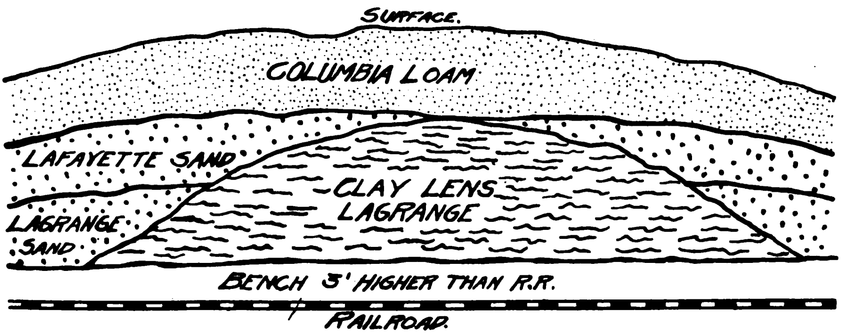


FIG. 6. EXPOSURE SHOWING CLAY LENS IN SOUTHERN RAILROAD 2 MILES EAST OF MOSCOW, TENN.

A well marked unconformity seems to exist here between the Columbia, Lafayette and LaGrange.

This clay is exposed on both sides of the cut, and is best seen on the south side. The hill extends about thirty degrees east of north. The area covered is about ten or twelve acres, and appears to be underlaid entirely by clay, as springs are found on the far edge from the railroad cut. The clay is gritty, and has fine sand partings, which divides it into layers, just enough sand being present to cause the clay to split. At the top, and down to 3 feet above the base of the cut, the clay is colored in spots a light yellow or pink, but at the bottom the clay becomes a light grey. The clay may make a fire brick, with the amount of silica that is present, while if this is washed out, a good potters clay would be gotten. A few years ago several carloads were shipped to Memphis for testing.

At the cut the overburden is 6 feet of loose sandy clay, which will increase to perhaps 15 feet in the highest part of the hill.

On Mrs. R. R. Wheeler's land at Moscow, is a deposit of molding sand, which is used by the Livermore Foundry, at Memphis.

Only about 2 feet of overburden has to be removed.

Somerville—Mr. F. H. Lightfoot planned several years ago to make brick. Machinery was bought, but operations were never commenced.

On the road from Somerville to Whiteville, clay is said to outcrop in gullies all the way from 1½ miles to 6 miles out. This was not visited.

GIBSON COUNTY.

Topography—Gibson County is situated in the north central part of West Tennessee. It is irregular in shape, and has as part of its northern boundary the South Fork of the Obion River, and as part of its southern boundary the middle fork of the Forked Deer. It has an area of 625 square miles.

The surface is mostly level, and slopes to the west, though in the eastern part of the county the surface is hilly and broken. The valleys are large and have wide flood plains. In the southeast an altitude of 500 feet is reached, while in the southwest, where the Forked Deer River leaves the county, the elevation is about 280 feet. The average elevation is about 400 feet.

Railways and towns—Three railroads enter the county, the Illinois Central, Mobile & Ohio and Louisville & Nashville. The Illinois Central traverses the central part of the county from north to south, while the Mobile & Ohio crosses the eastern edge in the same direction. The southeastern part of the county is crossed by the Louisville & Nashville Railroad.

The county seat is Trenton, situated on the Mobile & Ohio Railroad in the center of the county. Humboldt and Milan are junction points of the Louisville & Nashville and Illinois Central, and Louisville & Nashville and Mobile & Ohio railroads, respectively. They are very thriving towns. Other smaller towns situated in the northern part of the county, are Rutherford, Dyer and Bradford.

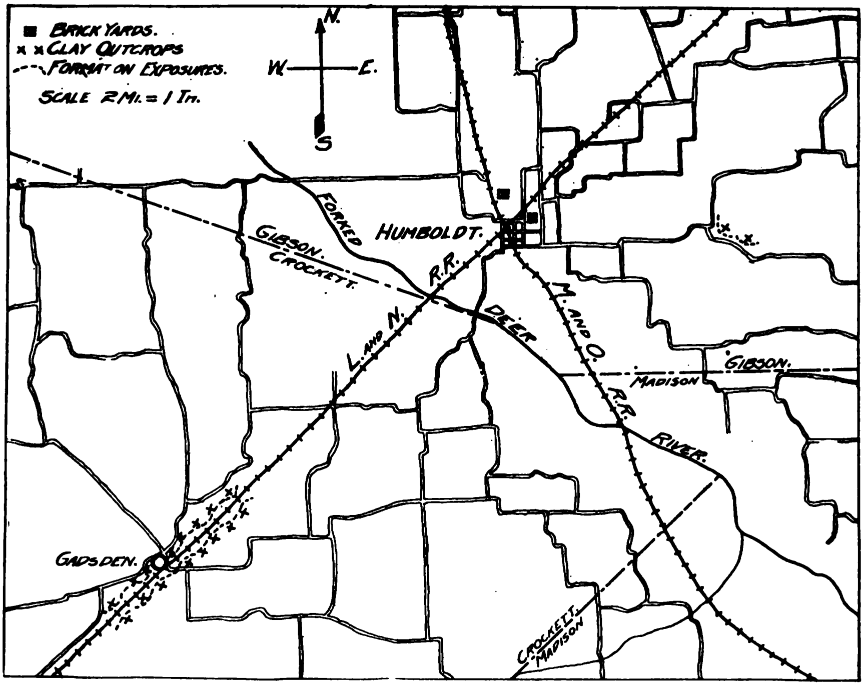


FIG. 7.

HUMBOLDT AND VICINITY. INCLUDING PARTS OF GIBSON, MADISON AND CROCKETT COUNTIES.

Geology—Three formations are exposed in this county, the LaGrange, Lafayette and Columbia loam and loess.

The LaGrange underlies the county, and is near enough to the surface in the eastern portion to be worked for clay, when it is present.

The Lafayette lies upon the LaGrange and forms the surface deposit in the eastern half of the county. It averages 20 feet, and is used for brick making in brickyards at Humboldt, Milan and Trenton.

The Columbia loam is only a foot or so thick, and is the soil layer. In the west this changes to the loess and becomes several feet thick.

Clay deposits—In the southeastern part of the county around Humboldt and Milan are several lenses of white sandy clay, located in the LaGrange formation. None of them are worked. As before mentioned, the Lafayette is used for brick making in the towns of Humboldt, Milan and Trenton.

Humboldt—A brick plant is located here, owned by McKnight Bros., of this place. Clay is taken from a pit, by the side of the plant, 2 to 8 feet deep, and over an acre in extent. The clay is of light red color, belonging to the Lafayette formation. It becomes very tough below the depth used.

This plant has been running since its establishment in 1902. The clay is brought by wheelbarrows to a chaser tempering wheel, which is run by a horse. After thorough working it is left to stand for twenty-four hours. The bricks are then hand molded, and placed in racks, which are under large sheds. The sheds have a capacity of 150,000, and the brick are air dried in them for about eight days. They have a repress machine through which they pass brick to make them smooth. There are three updraft kilns of 240,000 capacity, which use a burning system patented by John C. Boss, This is an underground air system. The air is forced up under the grates on which slack coal is used. A ten-horse power electric motor is used to run the blower, and all other machinery which is used. The brick are burned for eight days. The whole process of making a brick occupies six weeks.

Three kinds of brick are made: a common brick, a repressed brick, and an octagon brick for corners. One million bricks were made in 1910. They are shipped for a radius of 35 miles around Humboldt.

There is another brickyard located here, which was fitted up with steam driers and up-to-date machinery, but it has not been in operation for several years, and probably will not be operated again.

The following is a record of the deep well at Humboldt, which was stopped July 11, 1905, at a depth of 840 feet without striking water. Complete samples were taken of the different rocks and put in glass tubes and labeled. This would be a great help if it were done in all deep wells, as from such data the formations could be easily traced:

Record of waterworks well, Humboldt.

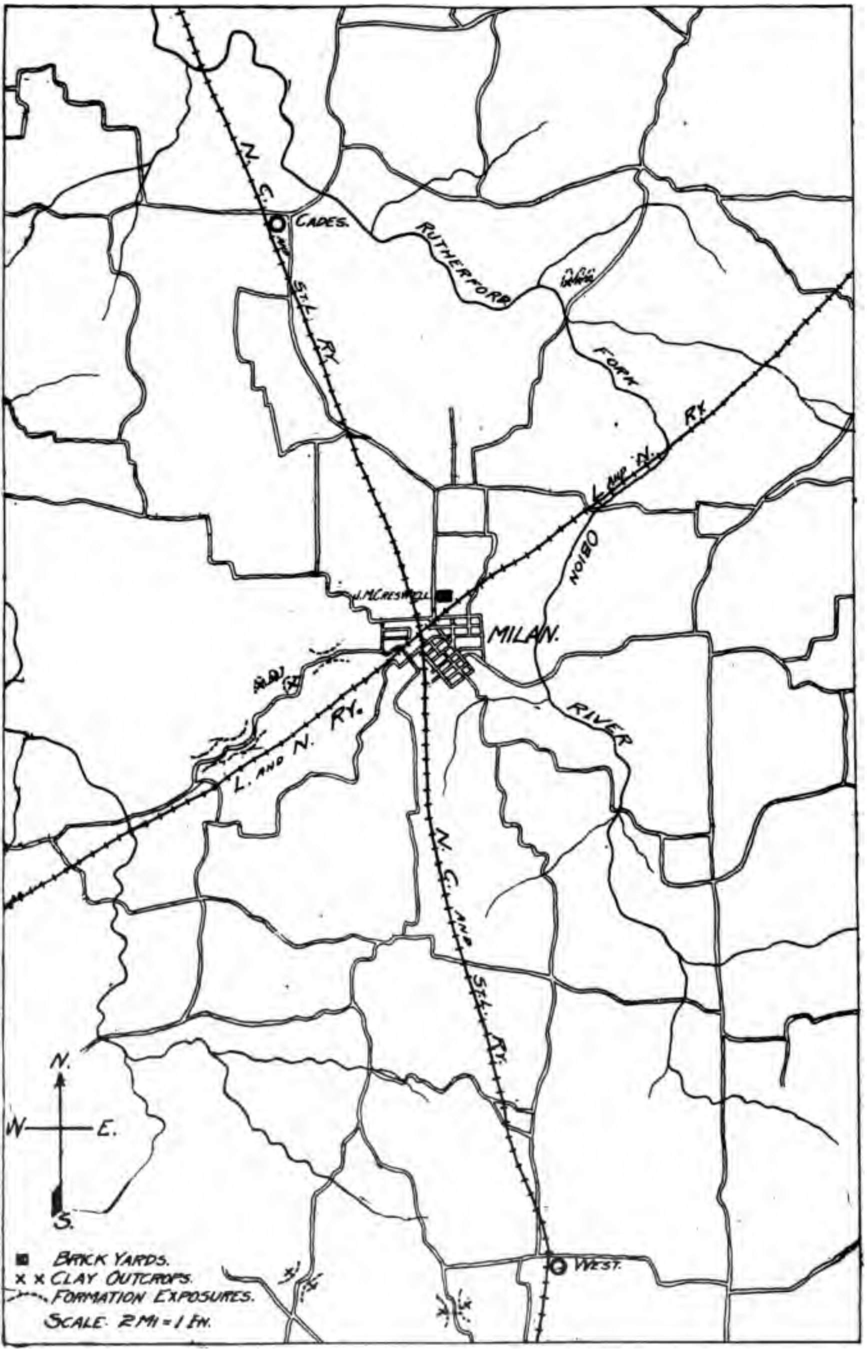
	Thickness	Depth
Light soil	5	5
Sandy red clay hardened	15	20
Bands of fine white sand and pipe clay, about 4 feet greatest thickness of layer	173	193

	Thickness	Depth
Coarse gravel up to ⅛ of an inch in diameter composed of quartzite, novaculite, and iron cemented sand grains. A fragment of a five sided coral was found. ⅛ inch cross section	214	417
White sand, 1–16 of an inch is largest diameter, slightly stained with iron	8	425
Same, only finer	10	435
Same, finer	3	438
Sand varied in colors, novaculite, quartzite, pink quartz and iron grains, average size 3–32 inch	1	439
Iron sand hard pan	1	440
Fine white sand, slightly stained with iron	20	460
Same, only a few mica flakes	10	470
Very fine white sand, mostly quartzite, a few dark grains	30	500
Iron stained sand 1-16 inch in diameter	6	506
Same, only more iron, looks yellow	4	510
Finer sand, less iron stain	3	513
Iron sand hard pan	1	514
Record from 514 to 542 lost.		
Hard sandy clay, yellowish, brown with black grains, sand particles very fine	44	558
Ironstone hard pan	1	559
Same, only harder	4	563
Ironstone hard pan	1	564
Very fine white sand, dirty looking	46	610
Same, only lighter in color, very little iron stain	5	615
Same	10	625
A brown black woody lignitic material, overlain by iron pan	23	648
Porter's Creek formation—		
An iron pan and then what looks like Porter's Creek clay (one fragment)	19	667
Fine dark grey sand	1	668
Porter's Creek clay greyish brown, with many mica flakes	14	682
Grey sand layers mixed with Porter's Creek clay	18	700
Brownish grey micaceous sand, semi-hardened	4	704
Same, lighter in color	44	748
Hard streaks of typical Porter's Creek clay and grey sand alternating	50	798
Light grey micaceous sand, harder and less mica present	12	810
Light grey, hard, little mica present	13	823
Very hard dark grey sand mica present, well stopped		840
Started with a 12-inch hole and stopped with a 4-inch one.		

From the samples of borings that were examined it would seem that the Porter's Creek commences at 648, and was still being bored into when the well stopped at 840 feet, making it have a thickness of 192 feet.

This would make the LaGrange formation 628 feet thick, overlain by 20 feet of the Lafayette. If these suppositions are correct, this

PLATE 9.



Map of Clay Outcrops at Milan, Gibson County, and Vicinity.

would make the Porter's Creek have a greater thickness than heretofore recorded. At Jackson, in the deep well, only 175 feet of it were encountered, while here they have passed through 192 feet, and are still in the bed.

The following exposure was seen two miles east of Humboldt on the Jackson road:

Road exposure 2 miles east of Humboldt.	Feet	Inches
Clay, light orange sandy to gravel	5	
Iron pan		2
Clay, sandy white, not uniform, streaked with pink, near bottom has sandy streaks	5	

This is a fair potters clay, or a fire brick clay.

Milan—A brick plant, owned and operated by Mr. J. M. Creswell, is operated here. It is situated on the north edge of town about half a mile from the railroad. The clay is mined from the surface down to a depth of 6 feet. At present only 3 feet have been dug. This pit is located by the side of the brick plant and covers several acres. Red Lafayette clays are used.

The plant has been in operation since 1901, on its present site. The clay is dug with a pick and carried by scrapers to the vats, where it is soaked over night. The clay next morning is dumped on a conveyer belt, which runs to the soft mud machine, which has a capacity of 20,000 daily. Ten men are required to operate it. A ten-horse power Waterloo gasoline engine is used to run the machine and conveyer. From the brick machine the bricks, which are placed on pallets, are carried to the racks, where they are air-dried out doors for 4 days. The racks have a capacity of 60,000 brick.

There are four updraft (Dutch) kilns of 20,000 capacity each. They are 28 feet wide, 52 feet long and 11 feet high. There are twelve "eyes" on both long sides. Wood is used to burn with. Ten days are required to complete a kiln burn.

A common wet mud brick is made. They are shipped as far as Bradford and to Toone on the Illinois Central Railroad, while on the Louisville & Nashville Railroad they are shipped as far as Trezevant and Stanton.

A new well has been completed at the waterworks, 113 feet deep. The following log was given from memory by the engineer in charge:

Record of well at Milan.	Feet
Sand, red	40
Clay, pipe, upper part white, while the lower was bluish grey	45
Sand, coarse white	12
Sand, fine white	8

On the lower road to Trenton, 1½ miles from Milan, the following exposure was found:

Section 1½ miles from Milan.	Feet
Soil, light yellow sandy	3
Clay, soft dark orange sandy	4
Sandstone, cross-bedded, hardened, with clay pellets, no gravel	13
Streak light yellow sandy clay	1½
Sandstone, cross-bedded, hard, not as dark orange as preceding, to foot of hill	12

In a gully 200 yards to the north of the road a good white sandy fire brick clay was found. In places the clay was light grey and contained leaf impressions scattered through it, though not in profusion, as in some other beds visited. It was covered by 2 feet of light orange sandy clay. On the highest point of the hill the overburden would not be more than 15 feet. A pit, if opened here, could easily be drained into a nearby gully.

On the second hill back of the lower road to Trenton, 1½ mile out, there are some other gullies showing good exposures of clay.

On top of the clay is 4 feet of light orange sandy clay not hardened. This will not increase to more than 12 feet in the deepest place. The clay extends down to the base of the gully a distance of 12 feet. The upper 2 feet is streaked with iron, and is less sandy than the remainder. The deposit is a very sandy, fine grained white clay.

These deposits are near enough to the town or the railroad to be shipped or worked. As the clay seems very free from all impurities but sand, washing might leave a good ball clay.

About 1 mile from town, on the lower Trenton road, the following sketch was made of the road sides:

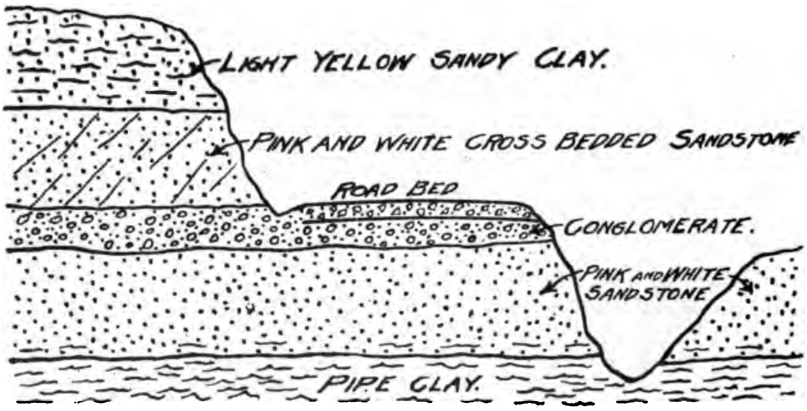


FIG. 8. CROSS SECTION OF ROAD SHOWING SURFACE FORMATIONS, 1 MILE WEST OF MILAN ON LOWER TRENTON ROAD

The bottom clay is an impure potters clay, with too much overburden to admit of working. No gravel is found anywhere except just under the road where there is a band about 1 foot thick cemented together, the intestices being filled with sand.

Three miles north of Milan, on the Trezevant road, about 150 yards to the west, the following exposure was found:

Section 3 miles north of Milan.	Feet	Inches
Sands, dark orange, lower 4 feet cross-bedded and case-hardened	10	
A band of white plastic clay with yellowish tinge	4	3
Iron hard pan		1–2
White sand hardened, has a pinkish tinge in places to bottom of gully	15	

This sand is the nearest approach to a glass sand found in West Tennessee. It might be washed and used for such a purpose. There is a large quantity of it, as it is exposed along the face of the hill for about 200 yards. It probably covers at least 25 or 30 acres.

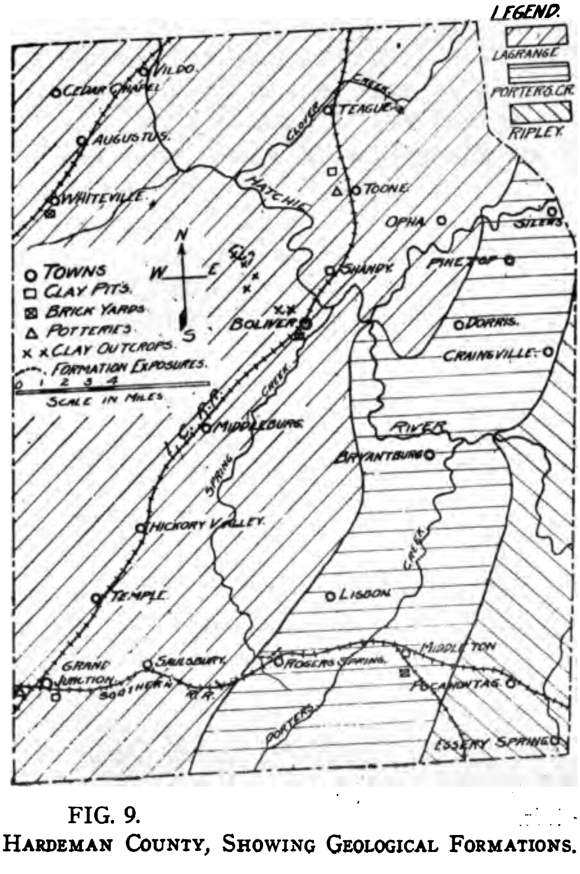


FIG. 9.
HARDEMAN COUNTY, SHOWING GEOLOGICAL FORMATIONS.

On the northwest side of the Louisville & Nashville Railroad, two miles southwest of Milan, about 12 feet of white sandy clay are exposed to base of cut, overlaid by 5 feet of light orange sand. This clay is of the same kind as that found on the lower Trenton road.

Trenton—Bricks are manufactured here by J. W. Barrett. The plant is located a half mile south of corporation limits, where the clay is also procured. The plant was started twenty years ago. The surface Lafayette clays are used down to 3 feet. This clay is mixed with the surface soil for making the bricks, one-third soil and two-thirds clay being used. The clay is dug in the winter and permitted to weather, as this improves its plasticity. Brick are made only during the summer.

The clay is mixed or tempered by a chaser wheel, which runs in a circular pit 18 feet in diameter and 18 inches deep, with a wooden floor. There are three pits, and the wheel is moved from one to the other. The clay, after being mixed, is allowed to stand over night. It is then hand molded into bricks. The daily capacity is 5,500. The bricks are then placed on open air racks and dried for a week.

The kilns are of the scove type, and are built up each time. They are made to hold from 100,000 to 200,000 brick. They are forty brick high and 18 feet wide, with walls 13 inches at the base and 9 inches at the top. The "eyes" are made 17 inches from center to center. The bricks are dried and burned with wood, it taking four days to dry and seven days to burn them. (See plate 5, Fig. A.)

The only brick made are mud pressed, and most of them are sold locally. A few are shipped in a radius of 30 miles. Only 600,000 were made in 1910, which was below the general yearly run.

HARDEMAN COUNTY.

Topography—This county is situated in the south central part of West Tennessee, and is rectangular in shape, containing 655 square miles. It is bounded on the south by the State of Mississippi.

It is drained into the Mississippi, through the Hatchie, Loosahatchie and Wolf Rivers, the Hatchie draining almost the entire area as it runs through the county from the southeast to northwest. The county is very hilly in the southern and northeastern part, while the western and central portions are slightly rolling or level. The lowest point is 300 feet above tide, where the Hatchie leaves the county, and the highest is over 600 feet in the southwestern part, where portions of the old plateau are left.

Railroads and towns—The county is entered by three railroads, the Nashville, Chattanooga & St. Louis, which cuts off the northwest corner, Illinois Central crossing from northeast to southwest and Southern crossing the south edge.

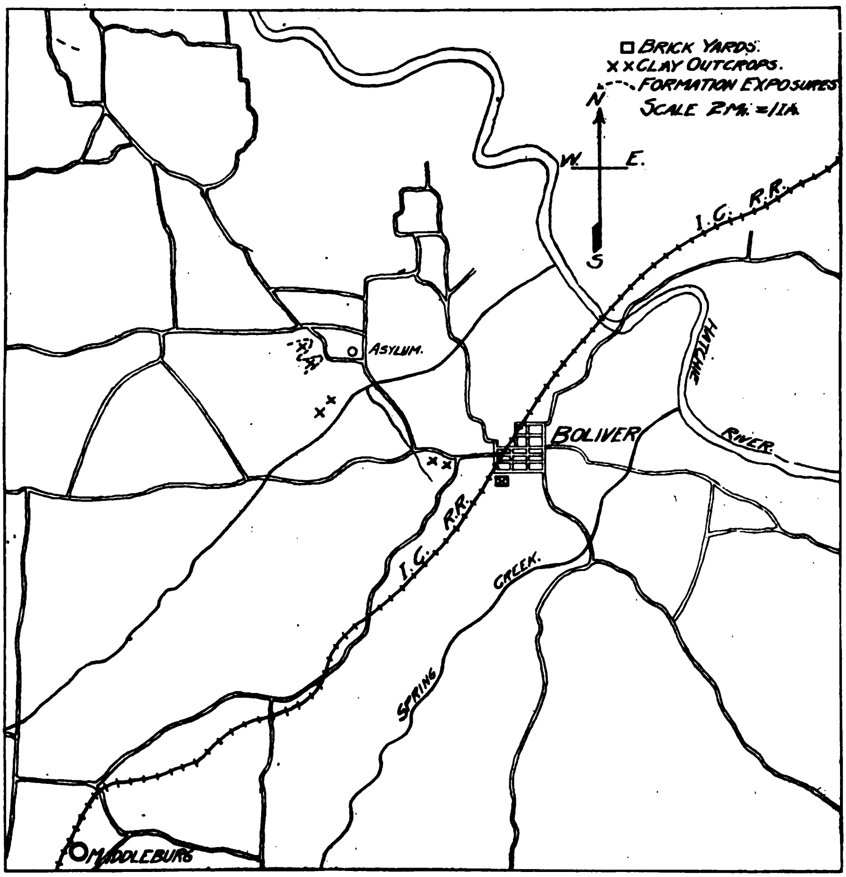


FIG. 10.

BOLIVAR, HARDEMAN COUNTY AND VICINITY.

The county seat and largest town is Bolivar, which is situated on the Hatchie River and Illinois Central Railroad. It is one of the oldest towns in this portion of the State, some of its first citizens having founded Memphis. At that time a line of steamboats ran on the Hatchie from Bolivar to Memphis. The river is not navigable now. Two miles west of Bolivar is located the West Tennessee Hospital for the Insane. The only other towns of importance are Grand Junction in the southwest, where the Illinois Central and Southern cross; Middleton on the Southern in the southeast corner of the county. In the north, Whiteville on the Nashville, Chattanooga & St. Louis, and Toone on the Illinois Central, are the best towns.

Geology—Over one-half of the county is underlaid by LaGrange. East of this the Porter's Creek and Ripley outcrop in narrow bands. The whole county is covered by a thin blanket of Lafayette sands.

Clay deposits—No clays are worked in the Ripley or Porter's Creek formations in the county. Clay lenses in the LaGrange formation have been worked around Grand Junction, and Toone, while at Bolivar some unworked lenses were found. At several towns the Lafayette clays are worked for brick.

Bolivar—The Bolivar Brick & Tile Company is located here on the Illinois Central Railroad. The firm started operations in 1905. Surface clay is used down to 8 or 10 feet. This is red Lafayette clay. Below that depth it becomes too tough. The clay is hand mined, and carried by scrapers to the mixers. It is pulverized and run directly through a "Success" soft mud machine, having a daily capacity of from 20,000 to 25,000. The brick machine is run by a 50-horse power engine and 60-horse power boiler. The bricks are taken from the machine and laid directly on pallets, which fit in the drying racks. Here the clay is sun-dried for one week. The drying racks have a capacity of 200,000.

The kilns are of the Scove type. As a rule three or four of them are made with a capacity of from 250,000 to 350,000 each. Wood is used entirely in the drying and burning of the brick. It takes from eight to ten days to burn.

The brick are not repressed. The bricks are shipped about 60 miles north and south on the Illinois Central railroad.

West of Bolivar at the asylum—There were some old clay pits located in Buttermilk Creek on R. D. Cross' land, which is 1 mile southwest of the asylum. These pits were worked 15 or 20 years. They have been entirely filled in, and no outcrops could be found. As these pits are situated in the bottom of a creek, not well situated for working, they would require pumping machinery to drain. The clay was used for pottery, and was said to be of exceedingly good quality. There is probably 15 feet overburden, as the banks of the stream are 5 to 10 feet high, and the stream has filled in at least 5 feet.

A very good exposure of ball clay was found about half a mile west of the asylum on State land. A section of one of the gullies is as follows:

Section on Asylum land near Bolivar.

	Feet
Clay, light orange, sandy, soft at top, hardened at base, a few gravel scattered at the top	10–20
Gravel layer of quartzite, up to one inch in diameter	1½
Clay, light pink at top and white and sandy at bottom	6–8
Sand, white, fine grained, streaked with clay to bottom of gully	3–6

The hill lies about twenty degrees west of south and covers about 30 acres.

The clay is one of the best plastic found outside of Henry County. It is not sandy at the top and does not appear to have too much iron or other impurities in it to keep it from burning white. It has a conchoidal fracture and a smooth texture.

The overburden, which will not exceed 30 feet, is loose in most places and could be easily removed. Pits could be drained by the ravine to the east. They would be within one-quarter mile of the pike to Bolivar 2½ miles distant.

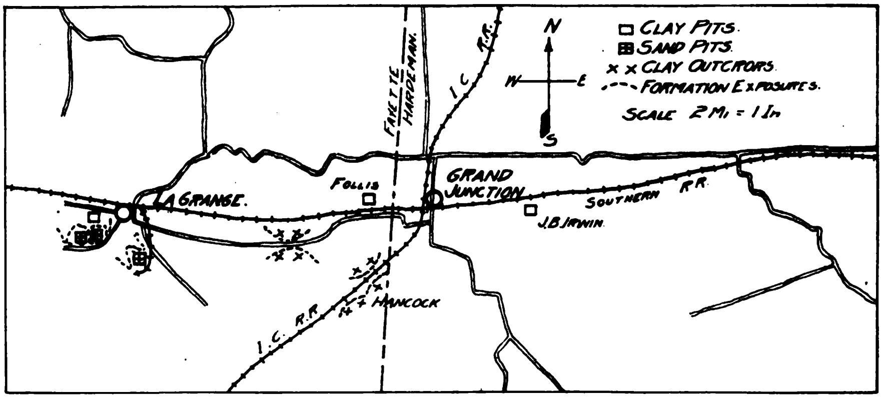


FIG. 11.

GRAND JUNCTION, HARDEMAN COUNTY, LAGRANGE, FAYETTE COUNTY AND SURROUNDING TERRITORY

A clay outcrops at the McNeal Spring on Mrs. Octavia Polk's land, about 1 mile from Bolivar, on the west side of the asylum road. This clay was used to make pipes.

All the wells bored in Bolivar have the following general section:

Section of wells bored in Bolivar.	Feet
Sand and red clay	65
Clay, solid, grey	25
Sand and clay mixed	100

Grand Junction—The Grand Junction Pottery, owned and operated by W. T. Follis, has been in operation here since 1901. Clay is gotten from the plant pits in Fayette County. (See p. 62.) The clay is ground in a wet wan crusher, which has a capacity of about 1 ton an hour. From the crusher it is taken and hand-welded by throwing it against a tightly stretched wire. The two pieces are taken up and pressed together and thrown again. The ware is molded on potters wheels, worked by footpower. For the small ware plaster of paris molds are used. The ware is steam dried for 24 hours, then glazed in Albany slip, or Bristol white glaze.

One downdraft beehive kiln with a capacity of from 6,000 to 7,000 gallons is used. It has a diameter of 16 feet and a height of 8 feet to the curve. At the base the walls are 5 feet thick. Coal is used for drying and burning, which occupies from 12 to 24 hours.

The following articles are made: churns, 1 to 10 gallons; jars, ½ to 20 gallons. Both these articles are made in molds up to 3 gallons; jugs, ½ to 5 gallons (½ to 2 gallons made in molds); flower pots, 5 to 12 inch, chambers 9 inch, chicken founts, ½ gallon; pitchers from 1 quart to 2 gallons are turned; also a few fire brick and sewer pipes are made for local use. The ware is mostly shipped south and west.

The Irwin clay pits are located 1¼ miles east of Grand Junction on the south side of the Southern Railway. All the clay in sight has been mined. This was tried by Mr. Follis in his pottery without success. The most extensive deposits here are sand.

Hickory Valley—Only poor sandy clay of no value was seen here. It was 2 miles southeast of town on the north side of the road. The following is the section seen:

Section at Hickory Valley.	Feet
Soil	1
Clay, light orange, sandy, upper part in bands of white and orange sand. Lower part hardened, and peppered with gravel	8–10
Clay, sandy, white, to case of gully	4–6

Another exposure of poor, sandy clay is seen 2 miles further on, in a gully on Mr. Woods' land.

A clay bed is said to outcrop on a Mr. Fergerson's land, 6 miles west of Hickory Valley. This was not visited.

Middleburg—There are some gravel pits located here from which sand is sometimes shipped into Memphis.

Middleton—Mr. J. D. Sasser, Sr., operates a brick plant here intermittently. It is located ¼ mile from the station on the west side of the branch road, which runs south to Mobile, Alabama. The plant has been idle for 2 years, but work is to be resumed this year. The clay used is the dark red Lafayette, the Columbia loam or sands being thrown aside. They have one stiff mud brick machine, with a capacity of 20,000 brick daily, operated by steam. The brick from this machine are placed in racks and dried for a week. There are four open air drying sheds, 15 by 150 feet. Scove kilns are used, taking twelve days to a burn and using ½ cord of wood for 1,000 brick.

The average yearly run is 200,000 brick, which are all used locally.

Rogers Spring—About 12 feet of fine, cream colored molding sand shows in a railroad cut on the Southern Railway, ¾ mile west of the station. It is overlaid by about 3 or 4 feet of overburden. It adjoins land belonging to Mr. Ike Chase, of Moscow, Tennessee. Mr. Chase also reports 20 or 30 feet of dark grey clay, black when wet, on a hillside 100 yards north of the railroad, and 1 mile west of Rogers Spring. The clay is overlain by 10 feet and more of overburden. This clay must belong to the Porter's Creek formation.

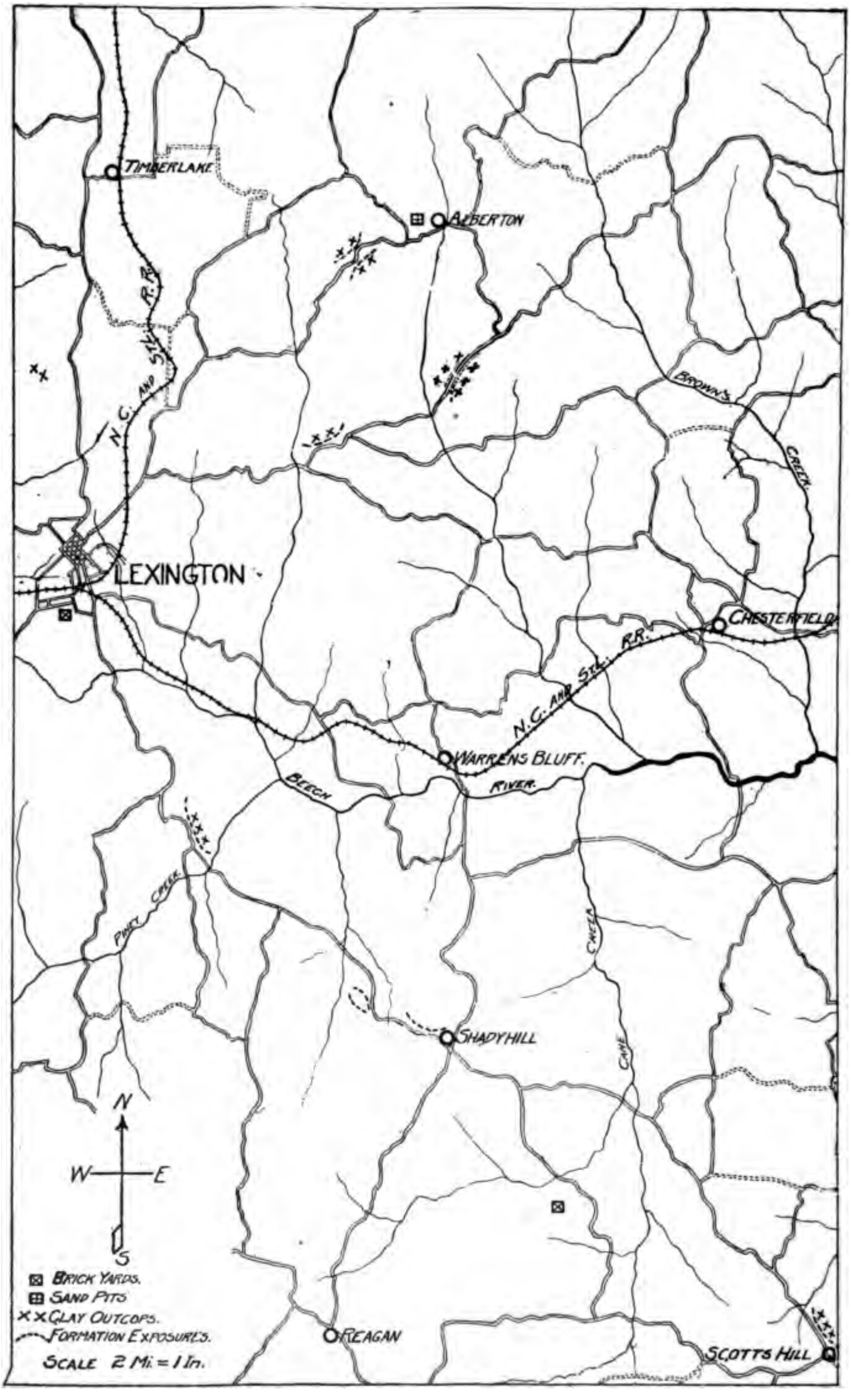
Saulsbury—Sand is shipped from here to Memphis by the Durden Sand Company.

Toone—Mr. R. B. Keller owns and operates a pottery on the western edge of Toone about ½ mile from the railroad. The clay is mixed and ground in an old wooden upright horsepower pug mill, then hand wedged, turned on potters wheels, and after sun drying for two days is burned in a downdraft beehive kiln, with 3,000 gallon capacity. Albany slip clay is used. Wood is used for the drying, 1½ cords being required; while 3 tons of coal are used in the burning.

The following ware is made: Churns, 3 to 6 gallons, jars 1 to 10 gallons, pitchers, ½ to 1 gallon, chambers, chicken founts, cuspidors, milk pans, flower pots, 6, 8 and 10 inches, and jugs 1 and 2 gallons. Nothing is shipped by rail, all is sold in the surrounding country.

The plant uses clay from a pit 2 miles north of Toone on Mr. Joe Pipkin's land. There are 2 to 8 feet of dark orange-red sandy clay overlying the clay, which is white, with slight yellow coloration in

PLATE 10.



MAP OF CLAY OUTCROPS AT LEXINGTON, HENDERSON COUNTY AND VICINITY.

places. This bed is 5 feet thick. Further up the ravine in which the clay is mined, a dark grey clay appears, which burns very white. This clay is about 7 feet thick, and overlaid by 2 or 3 feet of white clay.

There is also a small bed of white clay about 3 feet thick at the pottery, but it is too tough to be used. It is overlaid by 5 to 15 feet of overburden of dark orange sand.

Whiteville—A brick plant was started here in 1910. It is owned by Mr. Robert Richards, and managed by Mr. A. M. Moore. The plant is on the northwest side of the Nashville, Chattanooga & St. Louis Railway and 200 yards southwest of town.

The clay is dug from a pit, located by the side of the machinery. The clay can be used down to 15 feet. The first 4 feet is Columbia loam, the remainder is Lafayette red sandy clay, with iron specks scattered through it.

The clay goes direct from the pit to a steel No. 3 stiff mud machine, where a little water is mixed with it. The clay is forced out of a die (which is steam heated), as a long ribbon, which is cut into bricks of the required length. The machine has a daily capacity of 20,000.

The bricks are air dried for 2 days in a shed of 100 feet square. A steam dryer is to be installed so that brick can be made all the year.

One updraft kiln of 150,000 capacity was in use when the plant was visited. Two others are to be built this year. The process of drying and burning in the kiln occupies ten days, using wood.

Only dry press brick is made. Last year with a late start 250,000 were manufactured: They are used locally.

HARDIN COUNTY.

Topography—This county lies in the southeast corner of West Tennessee. It is bounded on the south by Mississippi and Alabama. The county has an area of 587 square miles, of this only one-third is located west of the Tennessee River, and in West Tennessee. This part of the county is cut up greatly by the small streams which flow into the Tennessee River. Back from the streams the surface is fairly level. The highest part of the county is along its western edge, with an elevation of 500 feet. Where the Tennessee River leaves the county, the river is 350 feet above sea level.

Railways and towns—There are no railroads in this county. Saltillo and Hamburg are the only towns of any importance west of the river, both are on the Tennessee River, the former in the northern part of the county, and the latter near the south. Savannah is the county seat.

Geology—The Eutaw sands, Selma clay and Lafayette formation outcrop in this county. Along the river are the Paleozoic limestones, then comes a narrow band of Eutaw sands, from 3 to 8 miles wide, while along the western border the Selma clay outcrops. The surface is covered with a thin blanket of Lafayette.

Clays—This county was not visited and no white clay deposits heard of. Along the river the decay of the limestones should yield a surface clay suitable for brick.

HAYWOOD COUNTY.

Topography—This county is situated just southwest of the center of this area. It is bounded on the north by the South Fork of the Forked Deer River. The county has an area of 520 square miles. The surface is a slightly rolling plain, with a gentle slope towards the Hatchie and South Fork of the Forked Deer River. The divide between these two streams runs directly through Brownsville, which is 344 feet above sea level. No deep ravines are found. The average elevation is 325 feet.

Railroads and towns—The Louisville & Nashville Railroad traverses the county, from the northeast corner to the southwest corner. Brownsville, located on it, is the county seat, and only town of any importance in the county.

Geology—The county is entirely underlaid by the LaGrange formation. This is covered by the Lafayette sands and clays in nearly every place. The Lafayette formation is from 10 to 20 feet thick, and in turn is covered by a light loam, which in the western part of the county changes to loess. This is from 5 to 10 feet thick.

Clay—The dark orange clays of the Lafayette are the only ones used here now for brick making. The LaGrange is covered too deeply to be exploited.

Brownsville—A brick plant is located here, which is owned by McKnight Brothers, of Humboldt. The plant is located just south of town, on the Louisville & Nashville Railroad.

The clay is gotten from the Lafayette formation, but is stiffer and will stand more heat than that which is used at Humboldt.

The clay is brought by a cart to a horse-power chaser tempering wheel. After a thorough working it is left to stand for 24 hours. The bricks are then hand molded, placed in racks, under sheds having a capacity of 150,000 and dried for about 8 days. There are three updraft kilns (Dutch), of 240,000 capacity, which use a burning system patented by John C. Bass. This is an underground air system. The air is forced up under the grates on which slack coal is used. An electric motor is used to turn the blower. The brick are burned for 8 days. The whole process of making brick occupies 6 weeks.

Only hand molded brick are made, which supply a wagon trade for a radius of 20 miles. In 1910 850,000 brick were manufactured.

HENDERSON COUNTY.

Topography—This county is situated just west of the center of the area under discussion. It has an area of 515 square miles. The Mississippi-Tennessee Divide crosses the county, running north and south. It has an elevation of 600 feet in places. The surface is very hilly along this divide and the eastern slope. On this slope the streams are rapidly cutting the surface. The principal river is the Beech River, which drains into the Tennessee. The western slope is cut up, not as badly as the eastern.

Railroads and towns—The Nashville, Chattanooga & St. Louis Railway comes down from the north to Lexington, the county seat and most important town in the center of the county. Here it turns southwest to the southwest corner of the county. A branch line also runs directly east from Lexington to the Tennessee River.

Geology—This county has more formations outcropping in it than any other county in West Tennessee. On the eastern edge is a strip of Eutaw sands, then comes a band of Selma clay; through the center of the county the Ripley extends as a band about 10 miles wide, while west of it the Porter's Creek outcrops, and in the northwest corner is a small area underlaid by the LaGrange. The whole county is covered by a thin blanket of Lafayette sands and clays, not more than 20 feet thick in any place.

Clay—No lenses of clay of good quality have been found in the Ripley sands in this county. The only clay used economically is that from the Lafayette formation, which is used in a few places for making brick and tile.

Lexington—Mr. J. C. White has stripped about 3 feet of red Lafayette clay for making a rough brick for 20 years. The clay is mixed and ground by tempering wheels, running in three circular pits. Six thousand bricks a day are hand molded, then sun dried for several days, and then burned with wood for ten days in a Scove kiln.

Last year 200,000 brick were made and sold locally. When out-of-town contracts are made, instead of shipping brick, a temporary plant is set up at the town and the brick made there. North of town on the road to Alberton, in a road cut about 5 miles from Lexington, a light yellow loamy micaceous clay was found. This clay is a phase of the Ripley formation that occurs in streaks in places. It looks greatly like an outcrop of the Porter's Creek formation and is easily mistaken for such.

Most of the exposures on the road to Alberton are of a dark orange sand, which for short distances is banded orange and white sand. This is particularly the case near Alberton, where the large hill is composed of such layers, in which the white predominates.

Four miles from town on the road leading to Scott's Hill, 8 feet of white sand are finely exposed, overlaid by 2 feet of light orange sand. Just beyond here the road commences to go down to Piney Creek. (For section of this exposure, see p. 12.)

Seven miles from Lexington on this same road a good exposure of the Selma clay was found. There are 6 feet of greenish micaceous clay, with shells scattered through it, which were overlaid by 4 feet of light orange sandy clay. Another exposure near here on the old road is given on p. 14.

At Scott's Hill, on the road entering town from Lexington, a fine exposure was found, which was described on p. 13.

On the road 3 miles west of Scott's Hill, on the edge of Cane Creek bottoms, Mr. B. F. McClanahan has started a brick and tile plant.

The clay is gotten from the surface and is used down for 4 or 5 feet. The clay is used in a stiff mud steel machine of the auger type, with a capacity of 8,000 daily. The die can be changed and 4-inch tiles made instead of brick. This clay is dried several days, and then burnt in a Scove kiln. The burning is done by wood, and takes 8 to 10 days. The kiln holds 75,000 brick.

Three miles north of Lexington, on the Huntingdon road, there is said to be a bed of light grey and pink sandy clay. It is covered by 2 to 8 feet of dark orange sand.

HENRY COUNTY.

Topography—This county lies in the northeast corner of West Tennessee. It is bounded by Kentucky on the north and the Big Sandy and Tennessee rivers on the east. The county has an area of 625 square miles.

The Mississippi-Tennessee Divide runs through the center of the county from north to south and divides it in half. The middle and north forks of the Obion River drain the west and the Big Sandy and Tennessee rivers the east part of the county. Along the divide the county is broken and hilly, the headwaters of the stream having made many gullies. East of the divide the slope is steep, but not as hilly, while west of it the slope is more gentle, and the surface changes to a

somewhat similar manner to the stalagmites found in caves. This gives

nearly level plain. In places, as in the northwest corner, the surface is greatly eroded. The highest part of the county is along the divide, where in places it reaches 600 feet. The average elevation is 500 feet, while the lowest is 300, where the Tennessee River leaves the county.

Railroads and towns—The Nashville, Chattanooga & St. Louis goes directly through the center of the county from north to south, and the Louisville & Nashville enters in the southwest corner, crosses the Nashville, Chattanooga & St. Louis at Paris, then goes due east and out of the county.

Paris is the county seat and largest town. It is located in the center of the county on both railroads. There are no other towns of any importance.

Geology—On the eastern edge of the county is a strip a few miles wide, where the Paleozoic limestones outcrop. West of this the Ripley formation outcrops in a band about 5 miles wide, which is bordered on its west by the Porter's Creek clay, which is about 4 miles wide. The western edge of this bed runs through the center of the county. West of this the remainder of the county is underlaid by the LaGrange sands and clays. The entire county is covered by a mantle of Lafayette, which is not more than 20 feet thick anywhere.

Clays—More white clays are worked in this county than all the rest of West Tennessee. The best pits are found along the eastern outcrop of the LaGrange formation, along the State line, and near the towns of Puryear, Whitlock, Paris and Henry. The other pits are found in the western edge of the Ripley formation near India.

These clays are good ball, wad and sagger clays, and are all shipped north to be manufactured into different kinds of ware.

Cottage Grove—Elevation 540 feet. All of this country is covered by several feet of Lafayette, with a band of concretionary iron and nodules at its base. Under that are the dark orange LaGrange sands, which gradually grade into a fine white sand, with narrow orange bands running through it. It becomes clayey at the base, and in places is underlaid by clay lenses of varying extent.

On the Bowden farm, ½ mile south of Cottage Grove, there is said to be a good outcrop of clay, which was hunted for, but not found.

On the Brizentine land, just north of town, are many deep gullies, which have exposures of 25 feet of a hard sandy clay, pure white. This clay, where it forms overhanging masses, has stalagtite-like pendants hanging from it, formed out of the clay, and caused by dropping in a somewhat similar manner to the stalagtites found in caves. This gives the gullies the appearance of the limestone walls of the caves found in the central part of the State. This bed is covered by 4 feet of orange sand.

This clay has an appearance of a good fire clay, but is too far from transportation for present use. It is directly on the line of the proposed electric railway from Paris, Tenn., to Fulton, Ky.

In another gully, 100 yards further north, the following section was found:

Section near Cottage Grove, Henry County.

	Feet
Lafayette:	
Light yellow clay, with iron Nodules at base.	2
LaGrange:	
Orange sand, hardened at base	6
White sandy clay, hard, changes to pink at the base, where a fossil leaf was found	15

It has joint planes, which run about fifty degrees west of north.

South of Cottage Grove, just below the blacksmith shop, is an exposure, in a small stream. The elevation is 480 feet. The bottom of the stream runs through a bed of poor lignitic material, which has been burned at times in the blacksmith shop. About 2 feet of it is exposed. It is overlaid by 15 feet of white sandy clay, and 5 feet of orange sand.

On the edge of town, on the Shankle place, some brick are being made by Mr. J. C. White, of Lexington, in a Scove kiln. Yearly capacity is 200,000. The surface clay from the Lafayette formation is used and mixed by a chaser tempering machine, and then hand molded.

This seems to be the western edge of the good clay lenses, and none are found west of a line drawn from here to Henry. The Mann pit is about 2 miles west of here. It is not worked at present.

Henry—On the road from Paris to Henry, 1½ miles from Henry, the following exposure was found.

Section north of Henry, Henry County.

	Feet
Lafayette:	
Clay, red sandy	5
Clay, light orange, with a sprinkling of gravel	12
Clay, white sandy	20

This clay is plastic, but has too much grit and other impurities to allow its use for anything but saggers. This outcrop is near enough the railroad to be utilized, but there are so many better pits nearby that probably it would not payto work it.

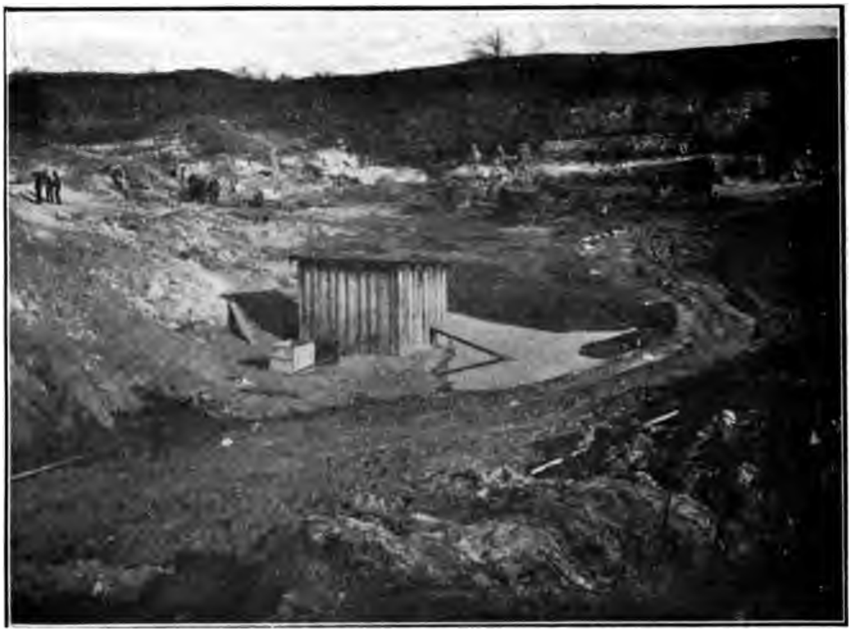


FIG. A. PIT NO. 10, JOHNSON-PORTER CLAY COMPANY.

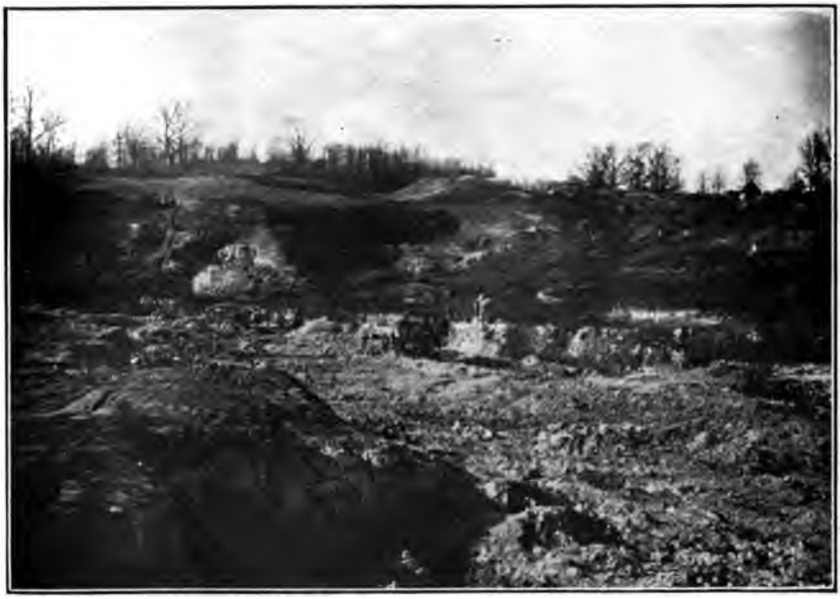


FIG. B. PIT NO. 11, JOHNSON-PORTER CLAY COMPANY.

CLAY DEPOSITS IN LAGRANGE FORMATIONS NEAR HENRY.

MoU

Two miles east of Henry, just east of the Paris road, is an outcrop of clay in a stream bed. The clay is very plastic and cream colored. It is underlain by a bed of lignitic material. Above the clay is 12 feet of whitish sand, with a little clay in it, while above that the orange sands extend 38 feet to the top of the hill. This is too deep an overburden to be removed; the clay could not be worked economically for this reason.

Johnson-Porter Clay Company—This company has pits located about ¾ mile above Henry on a spur track ¼-mile long. The offices are at Paris, Tenn., with Mr. Walter Johnson in charge. There are 2 pits located in 100 yards of each other—No. 10 and No. 11.

Pit No. 10—This pit is located right at the end of the spur track. The clay covers about 6 acres, and is a lens lying in the LaGrange formation. The thickness of the clay lens varies from 6 to 14 feet. (See Plate 12, Fig A.)

The following is a detailed section of the pit in its southwest side:

Section of Johnson-Porter Pit No. 10, *Henry, Henry County.*

	Feet	Inches
Sand, light orange	5	
Sand, dark orange	5	
Sand, banded white and orange	12	
Clay, dark brown, sagger	1	
No. 10 ball clay, mottles pink (Best in mine.)	5	
Lignite—grades into next		2 to 6
Dark brown sagger clay, in parts of the pit, it changes into cream or pink, while in the middle of the pit, they get a good ball clay—4 inches to	1½	

The top bed, which is a dark brown sagger clay in the southwest corner of the pit, changes in the northeast corner to a good ball clay. The bottom bed also changes from a sagger to a ball clay. This clay has a fine smooth texture and conchoidal fracture. It is one of the best ball clays found in the United States, and is extremely plastic. No grit or sand is present, and on a very slight amount of iron, under 1½ per cent. Some of the beds also have enough organic matter present to give them a grey color, but this readily burns out, leaving a white ware.

The pit has now become so deep that the water is pumped out of it into a nearby gully. The surface is hilly and covered with a scattered growth of second timber. The overburden is a loose sand, which is easily removed by scrapers. At one time a steam shovel was used. The clay is dug by spades and picked over, different grades being made.

The dirty ball clays are graded as sagger or wad. The clay vitrifies at Seger cone 9, while that from most of the Henry County pits vitrifies at cone 8.

Pit No. 11—This pit adjoins No. 10 on the north side, being about 100 yards distant. The clay lens extends about 20° south of east, and covers about 3 acres, but at present only about 1 acre has been worked. The clay beds have a maximum thickness of 7 feet, which pinches down to 5 feet in places. The entire deposit is capable of being worked, as the overburden is not too thick in any place. It varies from 3 to 5 feet where worked. (See Plate 12, Fig B.)

The following is a section of the pit on east side:

Section of Johnson-Porter No. 11 *Pit, Henry, Henry County.*

	Feet
Light orange sand, which changes into a white sand banded with orange streaks	3–15
Clay—mottled grey, used as sagger clay	1–2
Light grey ball clay, shipped as Tennessee ball clay No. 9. On the other side of mine it changes to a light pink and is shipped as Tennessee ball clay No. 11	4–5
Lignitic material	1
Sagger clay, dark grey	3

On the other edges of the pit the clay which comes from the lower layer is shipped as sagger, on account of grit which is present. On the western edge orange sand like that above the deposit is found. The clay is dug with spades, after it has been loosened up by a charge of powder. It is sorted and placed on wagons and carried to the cars where it is loaded. The overburden is stripped off by scrapers and part of it placed in the pit where the clay has been worked out.

The clay is a fine ball clay, very plastic, conchoidal fracture, and very fine grained and smooth.

This pit was opened about two years ago, and is considered to be better than Pit No. 10.

The clay from both pits is all shipped away to be manufactured. The following is a list of firms using this clay partly in the manufacture of their wares: Buffalo Pottery Company, Buffalo, N. Y.; United States Electric Porcelain Company, East Liverpool, Ohio; Pittsburg High Voltage Insulator Company, Derry, Penn.; Mayer Pottery Company, Beaver Falls, Penn.; Hall China Company, East Liverpool, Ohio; Keinworth Tile Company, Newell, West Va.; Wheeling Tile Company, Wheeling, West Va.; Cooke Pottery Company, Kittanning, Pa.; Vodrey Pottery Company, East Liverpool, Ohio; C. C. Thompson Pottery Company, East Liverpool, Ohio; Shenango Pottery Company, New Castle, Pa.; Cartwright Brothers, East Liverpool, Ohio; Owen

China Company, Beaver Fall, Pa.; Ohio Porcelain Company, East Liverpool, Ohio; Sebring Pottery Company, Sebring, Ohio; Sanitary Pottery Company, Tiffin, Ohio; Universal Sanitary Manufacturing Company, New Castle, Pa.; Findlay Electric Porcelain Company, Findlay, Ohio; G. F. Brunt Porcelain Company, East Liverpool, Ohio; and Gem Clay Forming Company, Sebring, Ohio. The firms manufacture all kinds of china and table ware, electrical insulators and decorative tile, sanitary ware, gas tips, etc. (See Frontispiece.)

The clay is shipped over the Nashville, Chattanooga & St. Louis Railroad. Three hunderd and twenty cars of clay were shipped in 1909, each car holding from 30 to 54 tons. Some years as many as 500 cars have been shipped. Up to date over 1,000 carloads of clay have been shipped from these two mines.

One mile southwest of Henry, on the Breedlove place, the old Nashville Pottery's pit is located. It has not been worked for several years. The following is a section of it:

Section of Nashville Pottery pit near Henry, Henry County.

	Feet	Inches
Dark orange sand, at the base banded streaks of white and orange	18	
Sand, light orange	2–5	
Iron pan		1–2
Sand, dark orange, cross-bedded	5–12	
Sagger clay, white streaked with yellow iron stains in places	6–22	

The clay lens is about 500 feet by 1,200 feet, and extends 30° west of north. The overburden does not increase to more than 20 feet in any place. This is very easy to remove, as it is composed of a soft, loose sand. The center of the old pit has been filled in with removed overburden.

The pit can be easily drained, as it is at the head of a ravine, into which the water will readily run.

The clay was shipped to the old Nashville Pottery Company, which has since then gone out of existence. It was used in making all kinds of stoneware. This clay could now be mined for saggers, and probably will soon be reopened. A lease is held on it by the Johnson-Porter Clay Company, Paris, Tenn.

On the same road, one-half mile further on, the pit of the Henry Clay Company, of Paducah, Ky., is located. This pit is 1½ miles southwest of Henry. Mr. J. C. Strop, of Henry, is in charge. The following is a section of the pit:

Section of Henry Clay Company's pit, Henry, Henry County.

	Feet	Inches
Clay, light grey, with pink spots in places	2	6
Band of Kaolin		3

	Feet	Inches
Clay, grey or pink	2	
Sand, light grey		5
Clay, dark grey, containing very numerous leaf impressions, this is called No. 3 clay	3	
Sand, light grey		3
Clay, light grey, grades into a pink clay which is cream colored in spots. This is the best clay in the pit	3	6

Then comes white sand.

This bed is made up of many thin clay layers interbedded with bands of sand or some worthless clay. Some of the layers are full of organic matter, others are slightly stained with iron. The clays are mostly coarse. This pit has more separate layers of clay than any visited, and on this account is expensive to work, as so much picking over has to be done.

The pit is on the side of a ravine, but has not been dug down so that it will drain. The water has to be pumped out. The clay is known to extend back at least 50 yards further, and its present width is about 50 yards. The overburden is removed by pick and shovel, and put in the part of the pit already worked out. The clay is dug in the same way after it has been loosened by blasting. The dug clay is carried by wagons to Henry, where it is shipped away.

Only one grade of clay is shipped, which is used for the manufacture of stoneware.

Two and one-half miles south of here there is said to be a small band of kaolin 12 to 18 inches thick. Also east of Paris about 12 miles is a small bed of kaolin, 16 inches thick, with more than 20 feet overburden. Neither one of these deposits were visited.

Palestine pit—The clay in this pit is similar to that found in the old Nashville Pottery pit on the Breedlove place. It makes a good stoneware. This pit is only worked intermittently, and nothing has been done there recently.

There is a small pit one-half mile north of Henry which is leased by Mr. J. C. Strop from which cars of stoneware clay have been shipped. This clay is only a fairly good grade. No ball clay has been found there.

Sparks' pit—About 5 miles west of Henry, and directly north of McKenzie, on the road to Como, is the pit of Mr. C. Sparks' Pottery, which is located in McKenzie.

The pit is located on the east side of the road on a steeply sloping hillside, and has been dug back into the hill about 100 feet, with a width of 50 feet. At present the pit is one-half of the time filled with water,

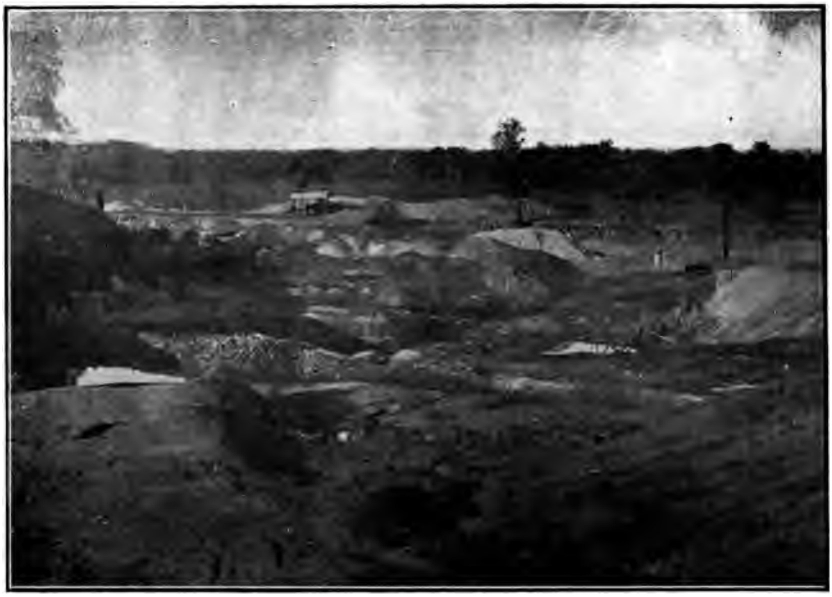


FIG. A. PIT NO. 3, MANDLE-SANT CLAY COMPANY. GENERAL VIEW OF PIT.

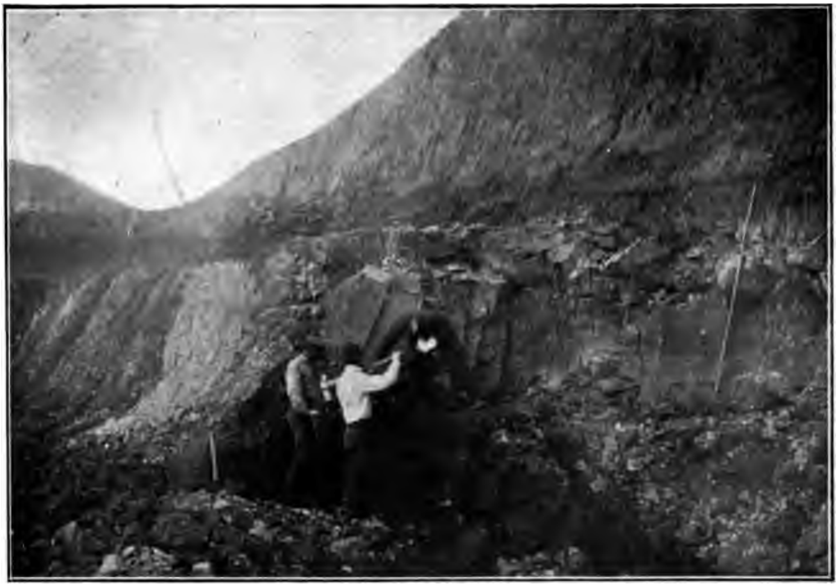


FIG. B. PART OF PIT NO. 3, SHOWING BROWN CLAY AND ITS CONTACT WITH OVERLYING SANDS.

CLAY DEPOSITS IN RIPLEY FORMATION, NEAR INDIA.

as the overburden taken from the pit has been dumped so as to interfere with the natural drainage into the nearby ravine. When visited, water was standing about 5 feet deep in the pit.

Section of C. Sparks' pit.

	Feet
Lafayette:	
Sand, light orange, darker at base and case-hardened, with a sprinkling of gravel	5-15
LaGrange:	
Clay, white with pink streaks, flinty fracture with slight incrustation of a white crystalline substance along the cracks. Clay turns to dark brown at 12 feet and then back to white at base	15

The overburden is so hard just above the clay that scrapers can not be used, so it is removed by picks in the same manner as the underlying clay.

The clay is hauled by wagon to the pottery, which is 6 miles distant at McKenzie.

India—About 1½ miles east of India is pit No. 3 of the Mandle-Sant Clay Company, St. Louis, Mo. (See Plate 13, Figs. A and B.)

The following is a section of the pit:

Section of Mandle-Sant Clay Company, India, Henry County.

	Feet	Inches
Sand, light orange, soft and loose	17	
Sand, black clayey film, tough 0 to	1	4
Clay, grey, water-stained in places. This clay is used	7	4
Clay, black loamy, very brittle, pyrite and lignitized wood scattered through it, not used	2	8
Clay, blue, very plastic	3	6
Sand and dirty clay, yellowish, of no value	1	6
Clay, brown, with a few small iron streaks, this clay is used	2	6
This clay grades into a bed of black clay which is not mined at present, thickness unknown.		

The blue clay is the best in this pit, and contains the least amount of sand. This blue gradually changes into the brown bed which is beneath it, which is a fairly good ball clay. The intermediate clay is worthless and is thrown away. All these clays have a great amount of organic matter in them, which give them a dark color. In most cases this burns out.

The following is an analysis of the clay*

Analysis of Tennessee ball clay No. 3.

Ultimate analysis.

Volatile	14.16
Silica	48.72
Alumina	32.89

---

*Carl H. Zieme, Feb. 22, 1907.

Iron oxide	2.25
Calcium	.60
Magnesium	.65
Potassium	.98
Sodium	.14
	100.39

Rational analysis.

Clay substance	89.04
Silica	9.64
Feldspar	1.32
	100.00

This analysis was made from an unwashed sample. The clay soaks up readily, and on sifting through a No. 12 lawn, a residue of from 10 to 15 per cent is left, which is mainly silica. Much of the iron is removed by the sifting. The clay is very plastic and will carry 72 per cent flint. When fired at cone 1, its shrinkage is 12.5 per cent, while it becomes 18 per cent at cone 8, at which heat it burns to a dense vitrified body of a greyish white color. It is very much like the English ball clays.

This clay lies on the western edge of the Ripley formation of Cretaceous age, in its upper part. The clay extends west from the edge of the pit for 400 yards. The overburden is a soft, loose sand, which is easily removed by scrapers, picks and shovels. The overburden gets thicker towards the west and probably reaches a thickness of 30 feet. At present the overburden is only 17 feet. The clay is mined by blasting first, then cut out with shovels and loaded on wagons and hauled to a nearby switch on the Louisville & Nashville Railroad. (See Plate 13, Figs. A and B.)

The clay is shipped to northern firms, some of which are: Lock Insulator Manufacturing Company, Victor, N. Y.; Hartford Faience Company, Hartford, Conn.; and Massillon Stone & Fire Brick Company. (See Frontispiece.)

One-half mile north of this pit is another small stoneware pit owned by the Mandle-Sant Clay Company.

The following section was gotten there:

Section of Mandle-Sant clay pit northeast of India, Henry County

	Feet	Inches
Orange sand	2	6
Gravel up to 2 inches in diameter; composed of quartzite and novaculite		10
Light red sand	2	6
Clay bed brown at top, grades into a greyish blue to base of the pit	9	

This pit is very small, only about 50 yards square. The overburden will increase up to about 10 feet as the pit is dug back. The pit will probably cover about 3 acres.

This clay is only used for stoneware. The pit will probably not be worked extensively, as the clay is of a poor grade for this territory.

New Boston—On the Hardin farm, one-quarter mile from New Boston, is a fine blossom of clay showing an exposure of about 10 feet. Borings in the center of the hill show an overburden of 30 feet of loose, orange sands. The lens covers about 110 acres, extending under the town and out on the other side of the Crawfords farm, and has a maximum thickness of 30 feet. This is directly along the line of the proposed interurban between Paris and Fulton.

This clay is very plastic and does not contain much grit. It is slightly stained with iron in places, and tests of burning from several samples have resulted in ware that is within grey in color. At present this deposit is too far from a railroad to be used. The nearest point is Paris, which is about 7 miles.

Paris—On the eastern edge of town is a brick plant owned and operated by Mr. Gatlin. The Lafayette clays are used down for several feet, the surface being discarded. The clay is tempered in an upright pug mill run by a horse. It has a capacity of 20,000 a day. The clay is hand molded and burned for 8 or 10 days in a Scove kiln, using wood. (See Plate 5, Fig. A.)

One and one-half miles east of Paris is another small brick kiln, exactly like the preceding. Brick are made only for local use.

Currier pottery and pits—Mr. J. T. Currier has two potteries near Paris, which have not been operated for several years. The principal plant is on the Louisville & Nashville Railroad about 1½ miles northeast of Paris. A pug mill was used for grinding and tempering the clay, and had a capacity of 11,000 a day. Two kilns were used, one a downdraft 16 feet inside diameter, with a capacity of 3,000 gallons; the second is a patent Howard kiln, with a capacity of 2,000 gallons. The downdraft kiln used coal and the Howard kiln used wood. The second pottery is half a mile east of the other, and has one downdraft kiln with a capacity of 2,000 gallons.

The ware made was mainly jugs. There is no longer a large demand for jugs, as at present glass bottles are taking their place in the bottling of whisky*

---

*Stoneware and brick clays, West Tennessee, by E. C. Eckel, U. S. Geol. Surv. Bull. No. 213.

The Currier pits are located about 1 mile east of the principal pottery. Below is a section:

Section of Currier pits, east of Paris.

	Feet	Inches
Loam, light yellow	2–3	
Gravel		1–3
Clay, sandy, yellowish	1–3	
Clay, greyish, not very uniform	5	

This pit was not visited, but it would seem from the other pits visited nearby that the clays found here are of the Ripley formation of Cretaceous age.

Puryear—There is a pit located one-quarter mile south of town on the west side of the Nashville, Chattanooga & St. Louis Railroad. It is leased by the Mandle-Sant Clay Company, St. Louis, Mo.

Section of Mandle-Sant Clay Company's pit, at Puryear.	Feet
Sand, orange, mostly gravel about 2 feet in diameter, with a few boulders over 1 foot in diameter scattered through it. The gravel is composed of quartzite and novaculite. There is an iron streak at the base.	5
Clay, white sandy, with yellow tinge, very hard. Has outward appearance of stalagtites where water has dripped over it	16
Clay, light grey, full of leaf impressions. This is a plastic clay and has little sand present	8
Clay, yellowish white. No fossils, very plastic	5

The top part of the grey clay is shipped as Tennessee ball clay No. 2, and is used for pottery. The middle of the grey clay is called Tennessee ball clay No. 3, and is less plastic than No. 2. It is used for tiles. While the lower part of the grey clay is called Tennessee ball clay No. 4, and is very brittle, being the poorest clay found here. The lower bed of yellowish white clay is shipped as Tennessee ball clay No. 5, and is used for saggers.

The No. 2 is the best clay. This pit was opened about 1904. It is drained from its western edge, the water being pumped out of the deepest parts by a small engine.

From the shape of the hill the clay lens must cover about 5 or 6 acres. The present pit only covers about an acre. The overburden should be easily removed, as the gravel can be sold for ballast, and the white sandy clay for fire brick to the plant just across the railroad track. Both of these beds could be utilized, and should pay for their removal.

The clay has been shipped north for use in the making of chinaware and insulators. The Dixie Fireproof Brick Company is situated across the track from the pit. Mr. Thomas H. McElrath is in charge. The plant was started in 1905. No brick have been manufactured for the last two years. The clay was gotten from the pit across the track and ground in a machine run by steam. The capacity was 50,000 a day. The bricks were dried in summer outdoors, while in winter steam heated drying rooms were used. There are two downdraft beehive ovens, 25 feet in diameter, and 8 feet high to the arch. The kilns were burnt with coal.

Two miles south of Puryear is a pit worked by Mandle-Sant Clay Company. There is no gravel on top. Orange sand of the Lafayette is present with a little gravel; then comes the fine white sand of the LaGrange formation. It is streaked in places with yellow, and case-hardened; then comes the clay bed 6 feet thick, which is dark grey, with fossil leaves scattered through it.

The Cosley Clay Company, of Mayfield, Ky., has a pit just south of the State line and 5 miles west of the Nashville, Chattanooga & St. Louis Railroad. The clay is shipped from Hazel, Ky. This was not visited.

Whitlock—There are five important pits located here, four belonging to the Mandle-Sant Clay Company, of St. Louis, Mo., and the other to the Tennessee Ball & Sagger Clay Company of the same place.

Pit No. 7—This pit is owned by the Mandle-Sant Clay Company, and is situated nearly three miles northwest of Whitlock. The pit covers several acres, and is the largest one in West Tennessee. (See Plate 14, Fig. B.) The whole clay lens has an area of 10 acres. The clay reaches a maximum of 8 feet and thins out from that towards the edges, where it disappears.

The following is a section of the pit on the south side:

Section of Mandle-Sant Clay Company pit No. 7, near Whitlock, Henry County.

	Feet
Orange sand, banded towards its base with sandy clay bands (12 feet)....	25
Clay, reddish brown	2
Clay, pink	2
Clay, sagger	1
Clay, grey, with organic matter present. This is the best clay	3

In the southwest corner all the clay is grey, with the exception of a band of pink about 1 foot thick above it. This grey clay is divided into two grades, a plastic and a nonplastic clay. The sagger clay, found under the pink, has a good binding quality, but too much iron.

The clays are shipped as follows:

Light grey clay—Tennessee selected ball clay No. 1
Mixed dark grey clay—Tennessee ball clay No. 1
Pink clay—Tennessee selected ball clay No. 7.
Mixed pink clay—Tennessee ball clay No. 7.
Sagger clay—Tennessee sagger clay No. 7.

Tennessee ball clay No. 1—It is very plastic, and has a tensile strength of the average English Ball Clay. It will bind 65 per cent of flint. It vitrified to a close dense body of excellent color at cone 8, and then showed a shrinkage of 15 per cent.

The following are analyses of an unwashed sample:*

Analysis of Tennessee ball clay No. 1.

Ultimate analysis.

Volatile	13.94
Silica	47.26
Alumina	35.85
Iron oxide	1.01
Calcium	.58
Magnesium	.68
Potassium	.74
Sodium	.45
	100.51

Rational analysis.

Clay substance	93.04
Silica	6.17
Feldspar	.79
	100.00

Tennessee ball clay No. 7—This clay is very plastic and soaks readily in winter. It burns to a dense nonabsorbent body at cone 8, and at that point shows a shrinkage of 15 per cent. It burns to a white color, and is used in the manufacture of white ware and tiles.

The following are analyses of this clay:

Analysis of Tennessee ball clay No. 7.

Ultimate analysis.

Volatile	10.92
Silica	53.57
Alumina	32.82
Iron oxide	1.31
Calcium	.62
Magnesium	.38
Potassium	.59
Sodium	.21
	100.42

Rational analysis.

Clay substance	83.39
Silica	14.78
Feldspar	1.83
	100.00

---

*Carl H. Zieme, 1907.

This pit was opened in 1905 and has been worked since then continuously. The overburden is easily removed by a steam shovel. It is loaded on cars on a narrow gauge road and carried away and used for filling.

The clay is first blasted and then dug out with picks and spades and loaded on cars and taken to Whitlock. (See Plate 14 B.)

The mine is reached by a narrow gauge road about 3 miles long, which runs to Whitlock. It is owned and operated by the Mandle-Sant Clay Company. The rolling stock consists of 24 dump cars and two small engines. The clay is shipped to Victor and Buffalo, New York, and East Liverpool and Zanesville, Ohio. It is used as an ingredient in the manufacture of wall tiles, white ware, insulators and faience.

Pit No. 4—This pit is one mile northwest of Pit No. 7, and is owned by the Tennessee Ball and Sagger Clay Company, of St. Louis, Mo.

The following is a section of the pit:

Section of Tennessee Ball and Sagger Clay Company, pit No. 4, near Whitlock.

	Feet
Sand, orange, white at the base	5–10
Clay, black lignitic	5
Clay, dark grey	6
Clay, light grey	12

Then comes a white sandy clay which is not used.

This pit is about 200 feet long and has been dug back 150 feet. It is in the LaGrange formation of Eocene age. The overburden is a loose sand, and is taken by scrapers and dumped on the hillsides. The clay is blasted and then mined by hand and hauled by wagons to pit No. 7, where the clay is loaded on the dump cars and carried to Whitlock. This clay is shipped north.

No analysis could be procured of this clay, which is shipped as Tennessee Ball Clay No. 4. It is a very plastic clay, and burns to a dense white body at cone 8.

Pit No. 9—This pit is owned by the Mandle-Sant Clay Company, of St. Louis, Mo., and is located 1 mile southwest of Pit No. 7. It is about one-half mile east of the road leading to Paris, and a little over 3 miles west of Whitlock. (See Plate 14, Fig. A.)

The following is a section of the pit on the south side:

Section of Mandle-Sant Clay Company's pit No. 9, near Whitlock.

	Feet
Sand, orange, lower part hardened and cross-bedded	4–20
Lignitic material, brittle and light in weight, brown in color	3
Ball clay, dark brown at top and light brown lower down	5
Sagger clay, yellowish, with iron stains	3

Under this is a white, very sandy clay, mixed with ironstone bands, which grades into a cross-bedded sandstone not very hard. All the clays are in the LaGrange formation of Eocene age. In places on the north side the lignitic material is replaced by a white sandy clay, which rests on the ball clay.

The clay vitrifies at seger cone 8, and has a total shrinkage of 16 per cent. It has very little free silica, a good percentage of feldspathic matter, and is very tough. It burns to a whitish grey, and closely resembles the English ball clay.

The pit covers about an acre. The overburden, which is mostly a loose sand, is removed by scrapers and dumped back of the pit. It will probably get 30 feet thick in places; the average is 15 feet. The clay is blasted and dug with pick and shovel, loaded on wagons and carried to the narrow gauge road at pit No. 7, and then loaded on the dump cars. It is shipped from Whitlock. The pit has a natural drainage toward the east into some nearby gullies. No pumping is necessary. The pit was opened in 1907, and has been worked since then, but in a desultory manner, and when visited only one man was digging there. The narrow gauge road is to be extended to this mine this year, and then operations will be opened up on a larger scale. The clays are shipped to the same places as that dug from pit No. 7.

Pit No. 1—This pit is three-fourth mile south of pit No. 9 and has been entirely worked out and was not visited. This is the oldest pit in the neighborhood.

Monroe wad mine—This mine is owned by Mandle-Sant Clay Company, of St. Louis, Mo., and is situated two miles north of Whitlock on the west side of the Nashville, Chattanooga & St. Louis Railroad.

This clay is one of the best wad clays offered to the trade, and is guaranteed not to "spit" or "fly" or stick to the saggers. It can also be used in the manufacture of architectural terra cotta. The following analyses have been made of it:*

---

*Carl H. Zieme, Feb. 22, 1907.

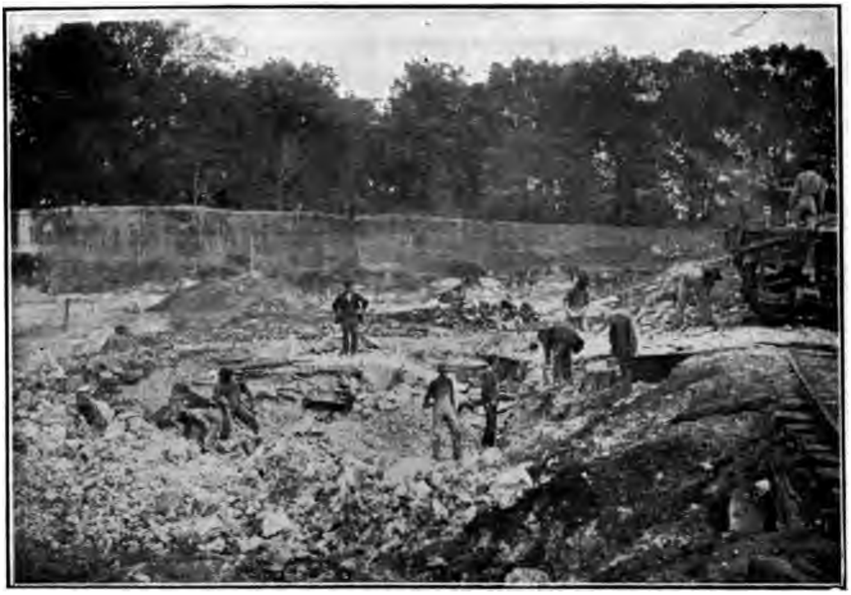


FIG. A. PIT NO. 9, MANDLE-SANT CLAY COMPANY.
Dark streak at left is a band of lignitic clay which changes in center of picture to a grey clay.

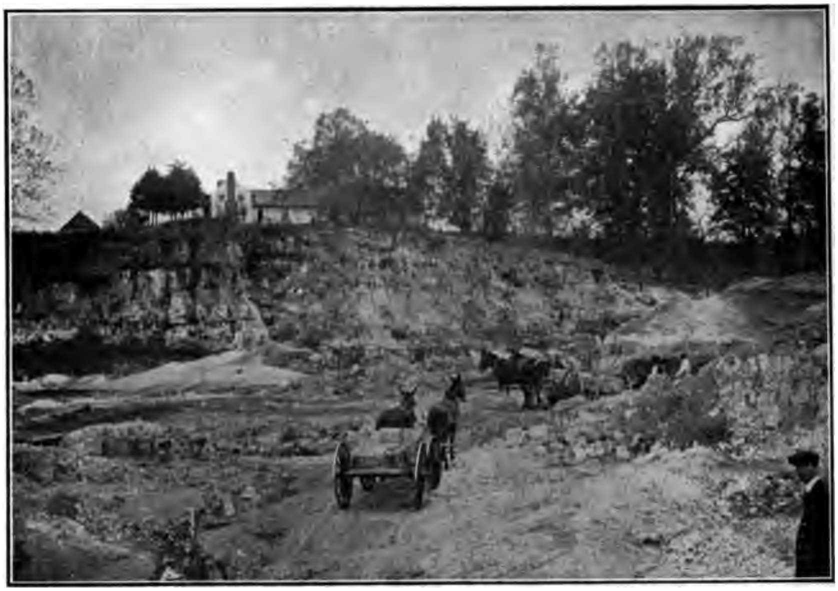


FIG. B. PIT NO. 7, MANDLE-SANT CLAY COMPANY.
Showing typical method of mining clay, and loading in dump cars.

CLAY DEPOSITS IN LAGRANGE FORMATION, WEST OF WHITLOC

Analysis of Monroe road clay.

Ultimate analysis.

Volatile	8.80
Silica	61.02
Alumina	26.32
Iron oxide	1.58
Calcium	.69
Magnesium	.83
Potassium	.65
Sodium	.18
	100.07

Rational analysis.

Clay substance	49.67
Silica	45.79
Feldspar	4.54
	100.00

This clay is taken from a lens in the LaGrange formation of Eocene age.

Jackson mine—This is a small mine located two miles east of Whitlock, which is similar to the other pits around here. It was not visited.

Routon—On both sides of this place indications point to extensive deposits of good ball clay. No borings have been made.

Vale—One mile south of this place, on the Nashville, Chattanooga & St. Louis Railroad, is an outcrop of white clay in a railroad cut.

LAKE COUNTY.

Topography—This county is situated in the northwest corner of West Tennessee, and lies between the Mississippi River and Reelfoot Lake.

It is a very small county, having an area of 128 square miles. The whole area is level, and has neither hills or ravines. Most of the area is subject to overflow, only having an elevation of about 300 feet. There is a slight southern slope to the county, being 315 feet high at the northern boundary and 290 feet on the south.

Railroads and towns—The only railroad in the county is a small branch line, called the Chicago, Memphis and Gulf, which runs to Tiptonville, the county seat, situated on the Mississippi River, and the only town of importance.

Geology—The whole surface is covered with alluvium from the Mississippi flood plain, which has a depth of about 100 feet, and is of recent age.

Clay—No clay products have ever been manufactured, and probably will not, as nothing could be used but alluvium, which would make a poor brick.

LAUDERDALE COUNTY.

Topography—This county is situated in the western part of West Tennessee, half way between its borders. It is bordered on the west by the Mississippi River, on the north by the South Fork of the Forked Deer River, and on the south by the Hatchie River. It has an area of 460 square miles. The western edge of the county lies in the Mississippi flood plain, and has an elevation of about 300 feet, and is perfectly flat, and subject to overflow. Then comes a line of steep bluffs from which the county extends backwards, deeply cut on the edges by the streams, while elsewhere the county is level or gently rolling. This plateau has an elevation of 350 feet. The South Fork of the Forked Deer and the Hatchie rivers have second bottoms several miles wide, which are about 15 feet above high water level.

Railroads and towns—One railroad, the Illinois Central, traverses the county through its central part, running north and south. The county seat and principal town is Ripley, which is on the Illinois Central, and in the center of the county. The only other towns of importance are Halls in the north, and Henning in the south, both on the railroad.

Geology—The LaGrange, Lafayette, loess, and alluvium, come to the surface in this county.

The LaGrange is rarely seen except along the base of the bluffs or in deep gullies or railroad cuts. Exposures were seen in the bottom of the railroad cuts at Ripley and Curve. At Curve the part exposed is a layer of dark blue lignitic clay below which is a fine quicksand.

The Lafayette here is mostly gravel or coarse sand, on account of the nearness to the Mississippi River. It overlies the LaGrange except in the bottoms where it has been washed away. It in turn is overlaid by the Columbia loess.

The Columbia loess extends over the county as a mantle, having a thickness of about 20 feet.

Clay—The only clay used is the loess, which is utilized in the making of brick in favorable places.

Ripley—Brick are manufactured here by F. M. McCabe & Co., of this place, who have been in operation three years. The plant is located on the south edge of town. The clay is taken from a pit by the side of the plant, and is used from the surface down to 25 feet, becoming better as it goes down. The clay is run through a disintegrator, which is a crusher with two large wheels, and then placed in a Hercules (soft mud) machine, which has a capacity of 35,000 brick daily. Some of the brick are repressed by a hand machine, which has a capacity of 2,000 a day.

The brick are dried out doors for one week in sheds which have a capacity of 129,000. They are burned in updraft kilns. There are two kilns of this type, which have a capacity of 500,000 and 400,000 each. Wood is used for drying and coal for burning, the whole process taking 14 or 15 days.

Common soft mud brick are made, and are nearly all used locally. A few are shipped. In 1910 they made 1,600,000 brick.

MADISON COUNTY.

Topography—This county lies just south of the center of West Tennessee, and has an area of 545 square miles. The county is drained primarily by the South Fork of the Forked Deer River. The western part of the county is level, the central part gently rolling, and the eastern and southern parts very hilly and broken. On the divides between the streams an elevation of 500 feet is reached, while, where the Forked Deer River leaves the county, the land is 315 feet above sea level. The average elevation is 450 feet.

Railroads and towns—Three railroads traverse the county, the Nashville, Chattanooga & St. Louis, the Illinois Central and the Mobile & Ohio. The latter two run through the county from north to south and cross at Jackson. The Nashville, Chattanooga & St. Louis Railroad also passes through Jackson, and runs through the county from east to west, leaving the county in its southwestern corner. Jackson is the county seat, and largest town, and is located at the junction of the three railroads. There are no other towns of any importance.

Geology—The Porter's Creek, LaGrange and Lafayette are found in this county. The Porter's Creek just enters the county in its southeastern corner, and runs along its edge from the point where the Nashville, Chattanooga & St. Louis enters to just north of where the Mobile & Ohio leaves the county. All the rest of the county is underlaid by the LaGrange formation, while the whole county is covered by a thin blanket of Lafayette sands and clays, which will not exceed 20 feet.

Clay—The clays of this county that are utilized come from the Lafayette and LaGrange. The Lafayette clays are only used for making common brick in a few of the towns, while the lenses of light colored clays from the LaGrange are utilized in several potteries and in one fire brick plant. No pure ball clays are worked here, all the lenses having clays which give a dark burn, but there are indications in several places that good lenses of ball clay might be developed. Outcrops have been found which give promise of better things under the hills.

Gilmore—The Southern Tile & Brick Works are located here on the west side of the Mobile & Ohio. The main office is at Jackson, and following are the officers of the company: W. P. Hunt, President; R. B. Hicks, Vice President; L. X. Wickersham, Secretary. The company was organized in 1903, and is the largest and most complete fire brick plant in West Tennessee. (See Plate 6, Fig. A.)

The pit is located on the west side of the plant, and the following is a section taken from it:

Section of Southern Tile and Brick Works' pit, at Gilmore.

	Feet
Clay, light orange sandy	6–15
Clay, white, streaked with iron stain, (grades into)	4–12
Clay, grey, which grades into black lignitic clay	34

The pit has only 25 feet of this bed exposed, but it has been found to extend down 9 feet deeper.

The clay is very plastic, and has a slight gritty feel. The following analysis was gotten of it from Mr. X. B. Wickersham:

Analysis of clay at Gilmore.

	Per Cent
Moisture	.98
Silica	77.83
Alumina	16.16
Ferric oxide	2.86
Loess	2.17
	100.00

Another analysis of a clay from this pit, probably the top layer, made by J. C. Wharton, of Nashville, in 1907, was as follows:

Analysis of top layer of clay at Gilmore.

	Per Cent
Moisture	5.60
The dried sample then gave as follows:	
Silica	41.03
Alumina	11.40
Ferric oxide	5.71
Calcium carbonate	35.71
Magnesia carbonate	2.99
Other substances unsought	3.46
	100.00

The black clay makes a white pressed brick, while a mixture of the brown and white clay makes a brown brick, while a strawberry red brick is made from a mixture of top red clay and white clay. The spotted brick are made by the addition of a little manganese. The fire brick will stand a heat of 2,800° Fahr.

The pit extends into the hill about 200 feet and is of about the same width. The overburden at present is about 10 feet, but it will increase to 25 feet where the hill is highest. Some of this can be used in a mixture with the white clay found underneath. The overburden is removed by scrapers to a small gully on one side, while the clay is loosened with powder, and then dug by hand and put in sheds to be used when the pit can not be worked.

The clay is first ground up in a heavy iron wheel in a dry pan, daily capacity of 35,000, and then passed through a sieve with one-sixteenth of an inch wire mesh. It is then run into the dry press machines, one a Burg press, with a daily capacity of 20,000, and the other a Reliance machine, with the same capacity, both being operated by steam and requiring four men each to run. The bricks go directly from the presses to the kilns.

There are nine kilns in operation, two updraft, with a capacity of 175,000 each, which take 20 days for a burn; seven downdraft, five with a capacity of 45,000 each, which are beehive in shape, have 12 "eyes," and require 8 days for a burn; two large ones, with a capacity of 175,000 each, which are rectangular, have 10 "eyes" to a side, and require 16 days for a burn. The drying out is done with wood and coke, and the burning with coal. It takes 20 cords of wood, 40 tons of coal and 10 tons of coke to burn a kiln of 175,000 brick. Several kinds of fire brick are made—the standard, split, side and bullhead size; also pressed front bricks of a light yellow mottled color and of a strawberry red. The daily capacity is 40,000 bricks. There is sold with the fire brick, ground fire clay, which is used to set them in, as no ordinary cement would do.

Jackson—J. B. Long manufactures common unpressed brick. The plant, which was established in 1904, is situated on the Nashville, Chattanooga & St. Louis Railroad on the southwestern edge of town.

The clay is used from the surface down to 3 or 4 feet. The surface is light yellow loam, while under it is the red Lafayette. These are mixed half and half in making brick. The clay is picked up, and then carried by scrapers to the nearby vats, where it is mixed with water and let stand over night.

A pugging machine of the chaser type runs in five pits, each with a capacity of 10,000 bricks, running three hours in each in succession.

The brick are hand molded, then dried outdoors about eight days in racks, with a capacity of 18,000, then go to the kilns. There are three updraft (Dutch) kilns, each with a capacity of 350,000 brick. The kilns are 21 by 75 feet and require about five weeks for setting up, burning and cooling. The drying out with coke takes about seven days, and the burning, with wood and coal for 8 or 9 days, requiring 50 tons of coke, 90 tons of coal, and 25 cords of wood. They made 2,000,000 brick in 1910, most of which were sold in Jackson.

Two miles from Jackson, on the pike to Gilmore, the following road exposure was seen:

Section in road near Jackson.

	Feet
Lafayette:	
Cross-bedded orange sand, no gravel, overlaid by light mantle of loam	15–30
White sandy clay to bottom of ditch	5–15

About 5 miles northeast of Jackson on the Brown's Church road a good road exposure of plastic clay was found. From the surface down to 6 feet was a light orange sandy clay with white sand bands, then came 4 or 5 feet of white sandy clay. At the bottom of the ditch on the east side of the road is a purplish plastic clay. The overburden on this clay should not exceed 20 feet in any place, as the hill under which it lies is low. Unless the clay should prove to be a good ball clay, it would not pay to work, as the deposit is over 4 miles from the railroad.

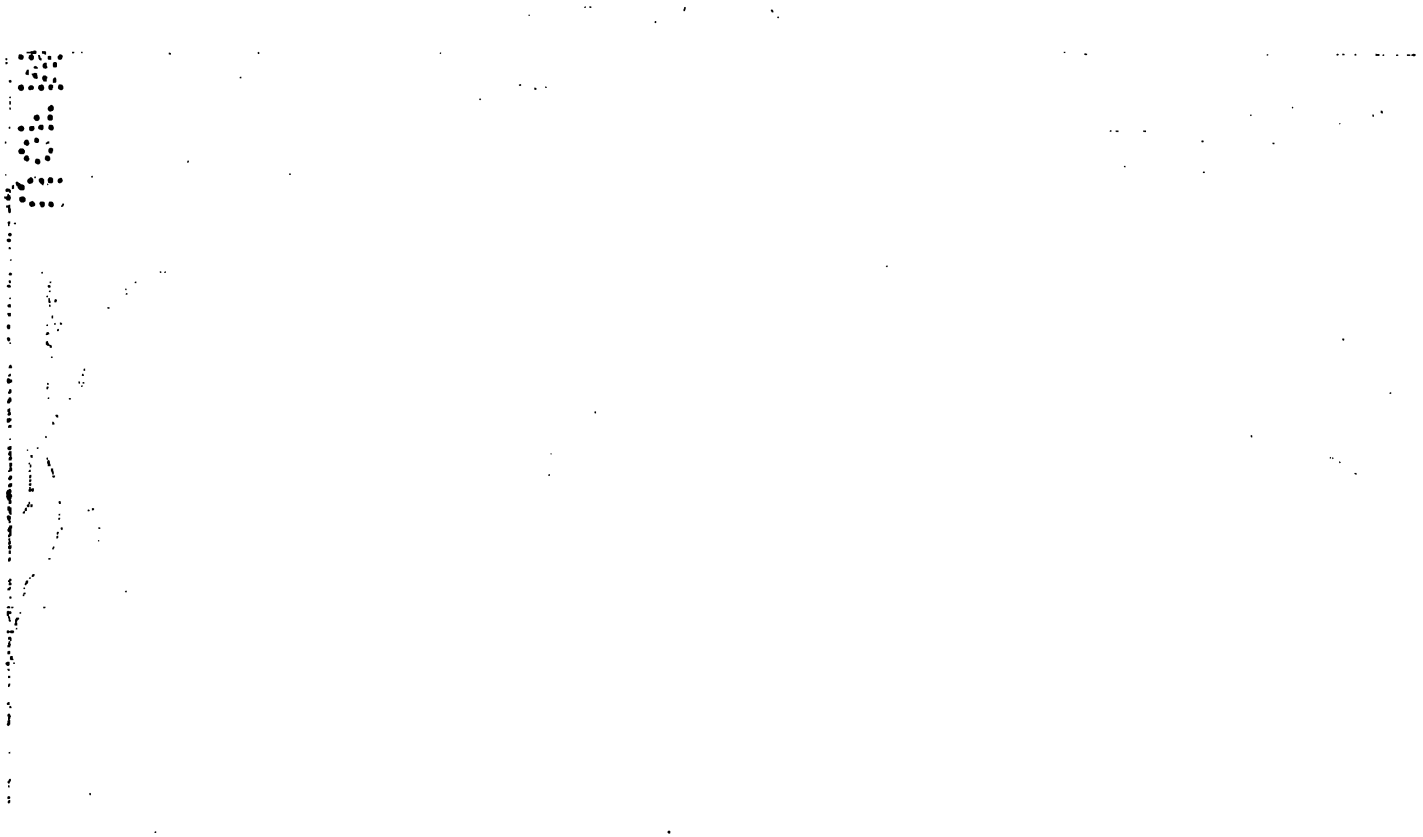
Two and a half miles from Jackson on the same road another roadside exposure was found, as follows:

Section on road 2½ miles from Jackson.

	Feet
Lafayette:	
Sand, light orange	5
Sand, orange, case-hadened with band of iron at base	5
LaGrange:	
Sand, white banded with orange sand,. to bottom of ditch	2

On the Spring Creek road 2 miles northeast of Jackson an exposure of clay was found in a roadside ditch. Just the edge of the lens, which extends back east from the road under a low hill, is exposed. The clay is plastic, but sandy. It is overlaid by 6 to 8 feet of light orange sand hardened at the base with an ironstone pan, broken in places, and resting on the clay. The hill lies a few degrees east of south.

PLATE 15.



On the edge of Jackson on the east side of the Spring Creek road the following exposure was found just beyond the bridge:

Section at Jackson.

	Feet
Clay, light orange, sandy	5
Sand, dark orange, with lignitic specks through it	12
Clay, dark grey, soft at top, while at the base it is hard grey rock. A small amount of mica is scattered through the bed	30
Clay, black, very plastic, looks like a ball clay, exposed to bottom of creek	4

The dark grey clay has all the characteristic marks of the Porter's Creek, but as it occurs about 12 miles west of any known outcrop, it could not be positively stated to be such, as there was not enough time available to trace it back to the main outcrops. It may be only a variation of the LaGrange formation.

Malesus—On the road 1½ miles east of this place the following exposure was found:

Section east of Malesus, Madison County.

	Feet
Clay, light orange, sandy	5–8
Clay, white, sandy, extends under the hill	6–12
Clay, dark, grey, sandy	1–2
Sand, orange, to base	3

The hill extends about 30° west of south, and covers 4 or 5 acres. The clay may be a fire clay.

Medon—There is a road exposure 1 mile southwest of Medon. White sandy clay was found about 12 feet thick, which was covered by about 6 feet of orange sand. The clay is of a poor quality and has been used.

A good exposure was found in a gully on Mr. S. C. Whitfield's place, situated on the road 2½ miles northwest of Medon.

Section northwest of Medon.

	Feet
Loam, light yellow	4–12
Lafayette:	
Clay, dark orange, sandy, no pebbles, case-hardened in places	4–14
LaGrange:	
Clay, white, very sandy, running to bottom of ravine. It is mostly sand and is streaked with purple and pink in places	25–40

About ½ mile further on and west of the road, the following exposure was found in some gullies:

Section 3 miles northwest of Medon.

Lafayette:	Feet
Loam, light yellow	4–6
Clay, dark orange, sandy	6–12
Ironstone nodules up to the size of an orange	6
LaGrange:	
Clay, white sandy, not very plastic	10–15
Sand, loose, creamed colored, to base of gully	3

Pinson—The Pinson Pottery Company is located here on the west edge of town. Mr. J. A. Harris, of Jackson, is interested in it. The pottery has gone down greatly in the last few years, and at one time was shut down entirely, while at present it is only operating on a small scale. The plant was established in 1898, but before that potters' ware had been made here for 30 years. A few fire brick are made along with the pottery, the same clay being used for both. The clay is ground up in a crusher and then tempered by hand welding. Everything but the jars and jugs are made in plaster of paris molds, though at present churns are made on a potters wheel, as well as the jugs and jars. These wheels at present are run by foot power, though they are fixed to be run by steam if so desired.

The following ware is made: Pitchers, ½, 1 and 1½ gallons; chicken founts, 1 gallon; jars, 1 to 10 gallons; churns, 1 to 6 gallons; bowls, ½ to 2 gallons; flower pots, 4 to 14 inches in diameter. No jugs are made at present, as they were used in shipping whisky, which is now bottled in glass.

Seven pounds of clay are used for 1 gallon vessel, which when dried weighs 6 pounds, and when burned 5¼ pounds, this showing the presence of 25 per cent of water in the green ware. A 2 gallon vessel requires 11 pounds of clay, a 3, 4, 5, 6, 7, 8, and 10 gallon require respectively, 15½, 18, 22, 23½, 32 and 38 pounds of clay.

The ware shrinks 1 inch to the foot, which is allowed for in its making. The drying is done in a room 100x13 feet, holding 5,000 gallons, which is heated by flues from three fire boxes at one end, using wood. After dipping in a slip of feldspar, ground flint and clay, the ware is put in two downdraft kilns (Stewart patent), one 18 feet in diameter, holding 6,000 gallons, the other 25 feet, holding 8,500 gallons. The burn takes 72 hours. Only the small kiln is now used, requiring 10 tons of coal.

Most of the ware is shipped south, some going as far as New Orleans.

The clay is obtained from about 3 miles west of Pinson, near Bear Creek. The following section was taken at the pit:

Section of Pinson pit, near Bear Creek.

	Feet
Clay, red, sandy	2
Ironstone pipes mixed with a light orange sand	12
Sand, cross-bedded, orange and white bands	12
Clay, dark grey, plastic, with lignitic specks in it, extends to bottom of pit	20

The hill runs 20° east of south, and covers about 4 acres. This pit has been dug down nearly to stream level, but natural drainage has been cut off by the method of handling overburden. The overburden is about 30 feet, and will increase to over 40 feet if the pit is dug back further. It is easily removed except where the iron pipes are cemented together. The clay is dug by hand and hauled to Pinson by wagons. The road is over 3 miles and very poor.

The clay is very plastic, of a light grey color, very similar to the lower layer of clay found in the pit at Gilmore, of the Southern Tile & Brick Works. It lies in the LaGrange formation of Eocene age. The following exposure was seen on Mr. Davis' land about 1½ miles south of the Pinson Pottery Company pit on the west side of the road:

Section of Davis' land, near Pinson pits.

	Feet
Lafayette:	
Clay, light orange, cross-bedded, sandy with clay pellets in it	6-8
Iron pipes	1
Clay pellets, white, sandy, up to one foot in size held together by a light orange sand, in which mica was present	12

This exposure shows that the original bed here had been eroded and that the pellets from it were deposited together with sand in the formation of another bed.

The Davis pit is nearly 2 miles south of the Pinson pit, and about 100 yards west of the road of Mr. J. T. Fields' land. The following section was found:

Section on Fields' land, northwest of Pinson.

	Feet
Sand, light orange, cross-bedded, with pellets at base	4-5
Clay, greyish white, a little sandy	20

This clay has sometimes been used by the pottery, but it was not quite plastic enough. The clay may make a fire brick, as it seems to have about the right physical properties. The overburden is hard in places, and will reach a maximum of 25 or 30 feet on top of the hill, but could be removed by picks. There is a good supply of water in the nearby streams.

Mr. J. L. Allen's pit is located on the Medon road, 2½ miles from Pinson. A light grey, plastic clay was found which is slightly sandy. It has an overburden of 12 feet of orange sand to the level of the road, while on the other side of the road the hill extends up 10 or 15 feet higher. This clay is one of the best near Pinson, and could be easily hauled there, as there is a good road all the way. It is not a ball clay.

On this same road, 2 miles from Pinson, on J. L. Allen's land, the following roadside exposure was seen:

Section on Allen's land, southwest of Pinson.

	Feet
Clay, light yellow, micaceous, loose and soft. Cross-bedded at the base. .	10
Sand, greenish, micaceous, with small amount of Glauconite	2

Both west and east of the exposure other road cuts show only a red cross-bedded sandy clay, which in places has gravel mixed in it. The gravel is composed mostly of quartzite, and is not larger than ½ inch in diameter.

From this it seems that the green sand and micaceous clay belong to a tongue of the Porter's Creek formation which extends up from the southeast where the main band lies. The green sand might be used as a fertilizer for the farms, as it has a small per cent of potash present.

MCNAIRY COUNTY.

Topography—This county is situated in the southeast corner of West Tennessee, and is bounded on the south by the State of Mississippi. It has an area of 570 square miles. The Tennessee-Mississippi Divide crosses the county from north to south, giving a third of the county to the Tennessee drainage and the rest to the Mississippi. This divide has an elevation of about 600 feet. The general surface of the county is about 475 feet above sea level. The surface is hilly in the west and southwest, while the east is more level.

Railroads and towns—The Mobile & Ohio crosses the county through its center from the north to south. Selmer is the county seat and only town of any importance.

Geology—Along the southeastern edge is a very narrow band of Eutaw sands, not extending more than a mile and a half into the county: next comes a band of Selma clay, about 8 miles wide, along the whole eastern edge, while the western half of the county is covered by the Ripley formation, with the exception of a few square miles in the northwest corner, where the Porter's Creek beds outcrop. The Lafayette covers the Ripley, but has been eroded away from most of the Selma clay.

Clays—The only clay used is that from the Lafayette, which is used in the manufacture of brick. Prospecting along the western edge of the county in the Ripley formation would probably bring to light some lenses of ball or potters' clay.

Selmer—No clay brick are made here, but Gooch & Harris, make a Sanderson patent brick, which is really a cement block colored red. The sand with which the brick is made is gotten from the Ripley formation. They have a daily capacity of 4,000 and made 30,000 last year. They are sold from $9.00 to $15.00 a thousand. None are shipped.

OBION COUNTY.

Topography—This county is in the northwestern part of West Tennessee next to Kentucky. It has an area of 505 square miles. A belt along its eastern edge a mile or two wide is low and subject to overflow, and the same is true of land on both sides of the Obion River, except drainage work has been done. Back from the Obion River is a second bottom 25 feet higher than the flood plain, which extends back several miles. All the rest of the county is much higher and changes from rolling to very hilly. The most hilly portion is just back of Reelfoot Lake—which is about 275 feet above sea level. The land is highest in the northern part of the county, where it reaches a height of 400 feet. The general elevation is about 350 feet.

Railroads and towns—Three railroads cross this county, the Nashville, Chattanooga & St. Louis traversing the northeastern corner, the Mobile & Ohio running along the eastern border and the Illinois Central coming in the northwest corner and going out in the south central part. This gives to the eastern section abundant railroad facilities and leaves the entire western part of the county destitute of facilities.

Union City is the county seat and most important town. It is located in the north central part of the county, at the junction of the Mobile & Ohio and Nashville, Chattanooga & St. Louis railroads, while the Illinois Central crosses the Nashville, Chattanooga & St. Louis only 3 miles from there at Gibbs. Other towns of importance are Obion and Kenton, both in the southern part of the county—the former on the Illinois Central, the latter on the Mobile & Ohio—and Rives in the central part, where the Illinois Central and Mobile & Ohio cross.

Geology—The formations found here are the LaGrange, Lafayette, Columbia loess and Alluvium. The LaGrange is covered everywhere except along the base of the lake hills. It is very clayey, but is too deep to be worked, as the clay is not of a high grade.

The Lafayette is found on the surface in the eastern part of the county in the uplands only. It is 20 to 30 feet thick, and is composed mostly of sand and gravel, the latter being very abundant near the river.

The Columbia loess lies as a mantle over the whole western half of the county, except in the bottoms it has been washed away and replaced by alluvium, as in the Obion and Reelfoot swamps. The loess is from 25 to 75 feet thick and lies on the Lafayette in the uplands, while in the second bottoms it rests directly on the LaGrange.

Clay—The only clay utilized here is the loess, of which two varieties are found and used. The light loess for brick and the dark for drain tiles, the latter being very plastic.

Obion—The W. M. Fox Tile Company, established in 1895, manufactures brick and drain tile. The loess is used to a depth of about 8 feet, below that it becomes too tough. The black and light yellow loess are mixed for making tile, while the light yellow is used alone for brick. The clay is taken directly to the stiff mud machine, which has a capacity of 15,000 a day, and is a combination machine for making brick or tile. The tile can be made from 4 to 14 inches in diameter. The bricks are dried in outdoor sheds, for about a week and then taken into the kiln.

Two downdraft beehive kilns are used, each with a capacity of 30,000. The kilns require three days for a burn, and wood or coal is used according to which is most convenient. When in operation the plant requires fifteen men. The tile are sold according to their size from $17.00 to $100.00 a thousand, while the brick bring from $5.50 to $7.50 a thousand. Most of the brick and tile are used locally.

Rives—The Rives Tile Company is located here, and is owned by the Foxes of Obion. It is operated by Mr. D. H. Woody, of this place.

A Keels' stiff mud combination machine for making either brick or tile is in use. It has a daily capacity of 15,000 brick.

In other respects the plant is like the one located at Obion.

Union City—The Union City Tile Factory, owned by Mr. R. M. Whipple, is located here on the Mobile & Ohio Railroad. This is the only special tile plant in West Tennessee, and it has been in operation for 35 years. It employes 26 men when in operation. The tile is made from a black loess, gotten from the side of the yard, which is dug down to 6 feet.

A stiff mud machine (No. 9 A) is used, which has a daily capacity of 10,000 4-inch tile. The tile are dried for 6 or 8 days, in three sheds, holding 10,000 4-inch tile. They are then burned in five downdraft beehive kilns 30 feet in diameter and 8 feet to the arch. Each holding 15,000 4-inch tile. Coal is used in the burning, which occupies 65 or 70 hours.

The T. L. Bransford & Sons' plant, in the northeast corner of the town, uses light yellow loess mixed with dark, gotten from the side of the yard, where it is dug to a depth of 6 feet.

The clay is soaked for 24 hours in two vats 12 by 30x4 feet, each holding material for 21,000 brick. It then goes by a belt conveyor to a Martin soft mud brick machine with a capacity of 21,000 a day. After air drying a week they are burned in Scove kilns 60 to 30 feet, holding 300,000 each for 13 to 15 days, using wood. The selected brick are shipped in a radius of 150 miles.

SHELBY COUNTY.

Topography—This county is situated in the southwestern corner of West Tennessee and is bounded on the west by the Mississippi River and on the south by the State of Mississippi. It has an area of 769 square miles. It is drained by the Loosahatchie and Wolf rivers. The county is low and swampy along the Mississippi River, except at Memphis, where the bluffs come up to the river. The two rivers also have flood plains several miles wide, and back of them a second flood plain about 20 feet higher, which is much more narrow than those found in Obion County. Three or four miles back of the Mississippi flood plain the bluffs which border the low plateau rise. This land is 50 to 75 feet higher than the flood plains, and is made up of gently rolling plains.

Railroads and towns—The following railroads converge from all directions at Memphis, on the Mississippi River, in the southwest corner of the county: Illinois Central, Louisville & Nashville, Nashville, Chattanooga & St. Louis, Southern, Kansas City, Memphis & Birmingham, and Yazoo & Mississippi Valley. Memphis is the county seat and also the largest city in the State, having a population of 131,105.

Geology—The county contains outcrops of the LaGrange, Lafayette, Columbia and Alluvium.

The LaGrange underlies the whole county. It is overlaid by the Lafayette in the uplands, and alluvium in the river bottoms. The Lafayette is not more than 30 feet thick, and in this locality is composed chiefly of gravel with some sands. Above it comes the loess which forms the river bluffs, and extends eastward, gradually thinning out and changing into a loam. The loess averages 50 feet in thickness along the bluffs. The flood plains are covered with alluvium, which reaches a thickness of 100 feet in places.

Clays—Only the loess is used in this county for making brick. No clay is being utilized from any other of the formations.

Capleville—The Nonconnah Pottery, located 1 mile east of Capleville, is owned and operated by Mr. W. B. Stevens. They make very pretty, artistic ware, consisting of jardinieres, jars and pitchers of various shapes. They are decorated with white enamel designs on a green base. After experimenting for several years, they started in 1909 to make ware on a commercial basis.

The local clay is gotten south of Capleville, just over the border in Mississippi. It is a light grey clay, which on burning turns to a light pink. In making the ware they mix with the local clay an imported red and white clay, with feldspar to make it tough. The ware after being molded is placed in a china ware kiln and burned to biscuit heat. It is then porcelain glazed and burnt under a temperature of 2,400° Fahr., which gives the ware a vitrous fracture. The decorative designs are burnt under a low heat.

Memphis—The Cubbins Brick Company, on the northeast side of town, has been in operation since 1890. The clay used is surface loess down to 4 or 5 feet. It goes from the pulverizer to the dry press machine, though in the summer some soft mud brick are made. They have two Fernel dry press machines of 20,000 daily capacity each, and one soft mud machine which has a capacity of 35,000 brick in 8 hours. The dry press brick are taken directly to the kilns and burned, while the soft mud brick are dried in racks out doors for a week before being burned. The racks have a capacity of 273,000.

They have seven updraft kilns, four with a capacity of 250,000 each, two of 400,000 each and one continuous kiln holding 400,000. The kilns are dried out with wood and coke, the process taking 8 days, then the bricks are burnt for 7 days with coal. Only two kinds of brick are made, a soft mud and a dry press brick.

Tennessee Brick Company—This company was established in 1890, and has been in operation since then. Recently it has been consolidated with the South Memphis Brick Company.

The surface loess has been used entirely, the first 6 feet for the dry press and the next 3 feet for soft mud machines. The bricks are made in dry press and soft mud machines. One hydraulic dry press of 40,000 daily capacity is used and two soft mud machines, which have a daily capacity of 31,000 each.

The kilns are of updraft variety and seven in number, having a capacity of 400,000 each. Wood and coke are used in drying the kiln and coal in the burning. The drying occupies 7 days and the burning 8 days. Most of the brick are sold locally, but a few are shipped to the surrounding towns.

South Memphis Brick Company—This plant is now consolidated with the preceding one, and manufactures the same class of brick.

Two Burg dry presses and two Success soft mud machines are in operation, the soft mud machines being used only in the summer, when outdoor drying can be done. They have seven updraft kilns, which have a capacity of 550,000 each.

Lyons Brick Plant—C. B. Lyons & Son have a brick plant located in Memphis which was started in 1910.

The surface loess is used to a depth of 15 feet. This is made into bricks by a stiff mud machine—with a daily capacity of 30,000—and a Grand Automatic soft mud machine—with a daily capacity of 30,000. The brick are dried in outdoor sheds, which have a capacity of 75,000 brick. There are two kilns, one downdraft, with a capacity of 80,000, and one updraft with a capacity of 300,000. Wood is used for burning the kiln, which process takes 8 days in the downdraft and 2 weeks in the updraft. Slabs of wood from nearby mills are used.

At times drain tiles are made in the stiff mud machines out of mixture of one-half Grand Junction clay and one-half loess.

TIPTON COUNTY.

Topography—This county is just next to the southwest corner of West Tennessee. It is bounded on the west by the Mississippi and on the north by the Hatchie River. It has an area of 430 square miles.

The western edge of the county is on the Mississippi flood plain and is very low and marshy. The Hatchie River also has a flood plain several miles long, as well as a second bottom, which extends back a short distance from the flood plain. The rest of the county is about 50 feet higher and gently rolling or level, except at the bluffs, where there are many steep hills.

Railroads and towns—The Illinois Central Railroad traverses the center of the county in a north and south direction. Covington is the county seat, and only town of any importance. It is located on the Illinois Central Railroad.

Geology—The LaGrange, Lafayette and Columbia loess are found in the county. The LaGrange underlies the whole county, and is overlain by the red Lafayette sands and clays. The formations are identical with those of Shelby County, just south.

Clays—The Columbia loess is the only formation used in the manufacture of brick. Only one plant is located in the county.

Covington—Mr. R. B. Shelton has operated a brick plant here since 1895. The loess is used down for 5 or 6 feet, below which it becomes too tough. The clay is dug and run directly into a stiff mud machine, with a daily capacity of 20,000. They also have a dry press machine, but do not use it. There are two updraft (Dutch) kilns, each with a capacity of 300,000, and one downdraft kiln with a capacity of 50,000. The kilns are dried for 1 week with wood, and then the burning, which occupies another week, is done with coal. The brick are used locally and shipped in a radius of 15 or 20 miles. Five miles south of here Mr. J. N. Rice makes clay pipes, using clay gotten 2 miles west of Covington, near Brighton, on the Illinois Central Railroad. The bowl of the pipe is made in a mold and then fitted to a cane stem.

WEAKLEY COUNTY.

Topography—This county is situated in the north central part of West Tennessee, and is bounded on the north by Kentucky, and on the south by the South Fork of the Obion River. Its area is 565 square miles. The surface is hilly around Dresden, and in the northeastern part of the county; the remainder of the county is gently rolling. Its general elevation is 425 feet, though in places 500 feet is reached, while in the west the Obion River is only 250 feet above sea level.

Railroads and towns—The Nashville, Chattanooga & St. Louis and Illinois Central cross the county, the former running from the northwest to southwest corner, while the Illinois Central runs north and south just a little west of its center. Dresden is the county seat, and a very prosperous town. Martin is the largest town in the county, and is located at the junction of the Nashville, Chattanooga & St. Louis and Illinois Central railroads. Other towns of importance are Gleason, Greenfield and Bradford.

Geology—The LaGrange, Lafayette and Columbia loam are found here. The LaGrange underlies the entire county. It is overlaid by about 20 feet of Lafayette formation, which here consists mostly of a red clayey sand, which in turn is covered in most places by a thin mantle of loam, 5 or 10 feet thick, while it is very similar to the loess.

Clay—Clays are only used to make brick and the Columbia loam is at present the only thing used.

Martin—A brick plant, owned by Mr. J. G. Walters, has been in operation here since 1895. The surface loam is used down to 3½ feet. The clay goes directly from the pit to a Monarch soft mud machine, with a daily capacity of 20,000. The brick are then dried for 1 week in outdoor racks, holding 250,000, and then put in kilns to be dried out and burnt. There are three updraft (Dutch) kilns, two holding 250,000 each, and one holding 300,000. They are dried out with wood and coke for 4 or 5 days, and then burned with coal for 1 week. The brick are shipped around in a radius of 50 miles. Only soft mud red brick are made.

INDEX

Figures in italics indicate principal reference.

—A— Page

Alamo 7
Alberton 81
Allen pit 106
Alluvium 8
Alluvial region 4
Analyses 26, 89, 90, 94, 97, 100
Asylum, Bolivar 74
Auger machine 34

—B—

Ball clay 14, 19, 38, 89, 94
Barnhart, Bill 44
Barrett, J. W. 72
Baxter Hill 55
Benton County 9, 11, *40*
Big Cut 12
Blue Cut 11
Bolivar 8, 27, 38, *74*
Bolivar Asylum 74
Bolivar Brick & Tile Company 74
Bowden Farm 83
Brackish water deposits 24
Bransford & Sons 109
Breedlove place 87
Brick clay 30
Brick labor 37
Brick molders 37
Brick output, 1910 38
Brick selling price 39
Brick setters 37
Brick wheelers 37
Brickyards at Bolivar 74
Brickyards at Brownsville 80
Brickyards at Cottage Grove 84
Brickyards at Covington 111
Brickyards at Dyersburg 59
Brickyards at Gilmore 100
Brickyards at Humboldt 66
Brickyards at Jackson 101
Brickyards at Lexington 81
Brickyards at Martin 112
Brickyards at McKenzie 50
Brickyards at Memphis 110

Page

Brickyards at Middleton 77
Brickyards at Milan 69
Brickyards at Obion 108
Brickyards at Paris 91
Brickyards at Puryear 92
Brickyards at Ripley 98
Brickyards at Rives 108
Brickyards at Scott's Hill 82
Brickayards at Trenton 72
Brickyards at Trezevant 52
Brickyards at Union City 109
Brickyards at Whiteville 79
Brizentine land 83
Brownsville 8, 38, *80*
Burning 35
Burning cost 35, 36

—C—

Camden 8
Camden chert 58
Capleville 109
Carboniferous 8
Carner, R. H. 58
Carroll County....
....11, 14, 15, 23, 25, 29, 30, *40*
Chandler, Mrs. Polly 46
Character of deposits 22
Chase type 63, 77
Chaser Mills 33
Chemical Analyses....
....26, 89, 90 94, 97, 100
Chester County 11, 14, *56*
China ware 22
Cities and towns 7, 8
Clay, ball 39, 89, 94
Clay, character of deposits 22
Clay, color of 28, 29, 30
Clay, definition 18, 19, 20
Clay, deposits of 41
Clay, drainage tile 20
Clay, fusibility of 28, 29, 30
Clay, fire 39
Clay, manufacture of 35, 36, 37
Clay, mining of 30

Page
Clay, miscellaneous 39
Clay output for 1909 39
Clay preparation 31, 32, 33, 34, 35
Clay resources by counties 40
Clay, sagger 19, 39
Clay, shrinkage of 28, 29, 30
Clay, selling prices of 39
Clay, stoneware 22, 39
Clay, Wad 19, 39
Cleaver, Jim 46
Coffee Bluff 9
Columbia formation 8, 14, 17, 27, 28
Common brick 20
Continuous kilns 37
Conveyors 31
Cooper, H. M. 47
Corduroying roads 7
Cosley Clay Company 93
Costen-Moore & Company 50
Cost of burning 35, 36, 37, 38
Cottage Grove 32, 38, *83*
Covington 8, 38, *111*
Crawford farm 91
Cretaceous 8, 9
Creswell, J. M. 69
Crider 1
Crockett County 24, 57
Crops 6
Cross, R. D. 74
Cubbins Brick Company 110
Currier pits and pottery 91
Curve 18
Cypress Station 3, 11

—D—

Dale 61
Davis pit 105
Davenport pit, Jim 61
Decatur County 9, 29
Definition of ball clay 19
Definition of common brick 20
Definition of drainage tile clay ... 20
Definition of fire brick 21
Definition of kaolin 18
Definition of potters clay 19
Definition of saggers clay 19
Definition of wad 19
Deposits, character of 22, 23
Development, general 6

Page
Dip 10, 13, 14, 15
Disturbances 5
Dixie fireproof brick 92
Downdraft kilns 37, 38
Drainage tile clay 20
Drainage 6
Dresden 8
Drying 35
Dry pan 31
Dry press 34
Dyer County 58
Dyersburg 7, 8, 38, *59*
Durden Sand Company 77

—E—

Earthquakes 4, 5, 6
Eckel 1
Electrical ware 22
Embayment clays 22
Eocene series 5, 8, 13
Eutaw sands 3, 8, 9, 10, 24, 25

—F—

Falkner, J. B., pit 45
Fayette County 24, 29, 30, *50*
Fergerson, Mr. 77
Fertilizers 6
Fire brick 21
Fire clay 39
Fire clay pit 52
Flatwoods 4, 5
Floodplain clays 25
Follis, W. T. 62, 76
Forked Deer 3, 19, 25
Formations described 8
Fossils 11, 15, 16, 44, 63
Fox Tile Company 108
Fresh water deposits 23
Friendship 7
Fusibility 28, 29, 30

—G—

Gatlin, Mr. 91
General development 6
General distribution of deposits .. 27
Geology of area 8
Geology of Carroll County 41
Geology of Chester County 56
Geology of Crockett County 57
Geology of Decatur County 58

Page
Geology of Dyer County 59
Geology of Fayette County 61
Geology of Gibson County 65
Geology of Hardeman County 74
Geology of Hardin County 80
Geology of Haywood County 80
Geology of Henderson County 81
Geology of Henry County 83
Geology of Lake County 97
Geology of Lauderdale County 99
Geology of Madison County 99
Geology of McNairy County 106
Geology of Obion County 107
Geoolgy of Shelby County 109
Geoolgy of Tipton County 111
Geology of Weakley County 112
Gibson County 7, 24, 29, 30, *64*
Gilmore 1, 27, 38, *100*
Glacial clays 24
Glenn, L. C. 12
Gooch and Harris 107
Gravel Hill 11
Grinding 31
Guy 11

—H—

Hancock pits 62
Hardin County 9, *79*
Hardin farm 91
Hatchie River 3, 18, 25
Haywood County *80*
Hardeman County ....
....3, 11, 14, 15, 23, 29, 39
Henderson County ..8, 10, 11, 14, 29, *81*
Henry 27, *84*
Henry Clay Company 16, 18, *82*, 87
Henry County ....
....3, 7, 11, 14, 15, 23, 25, 29, 30, 38, 82
Hico 24, 27, *41*
Hickory Valley 76
Hills of erosion 3, 5
Hollow Rock 23, 25, 27, *44*
Hollowleaf-Trezevant road 52
Humboldt 7, 8, 27, 38, *66*
Huntingdon 8, *47*

—I—

Ichthyosaurus 11
Illinois Central 6, 16
India 25, 27, *89*
Introduction 1
Iron pits 76

—J—

Jackson 3, 7, 16, 38, ***101***
Jackson Mine 97
Johnson-Porter Clay Company...... 85

—K—

Kansas City, Memphis &
Birmingham 6, 7
Kaolin 18
Keller, R. B. 77
Kentucky-Tennessee line 5
Kilns, continuous 37
Kilns, downdraft 37
Kilns, Dutch 36
Kilns, Scove 36

—L—

Labor of making brick 37
Lafayette 8, 14, 16, 17, 23, 27, 28
LaGrange 3, 15, *61*
LaGrange sand ..16, 24, 26, 3, 8, 14, 27
Lake County *97*
Lauderdale County 98
Lexington 8, 10, 11, 12, 38, *81*
Lignitic material 15
Lithological character ..9, 11, 13, 14, 17
Lightfoot, F. H. 64
Livermore Foundry 64
Loam 18
Loess 17, 25
Long, J. B. 101
Louisville and Nashville 6, 7
Lovin, L. L. 59
Lyons Brick Company 111

—M—

Machine-repress 35
Madison County ..7, 14, 15, 23, 29, 30, 39
Malesus 103
Mandle-Sant Clay Company....
....17, 27, 89, 92, 96
Mann pit 85
Marine deposits 24
Martin 8, 38, *112*

Page
McCabe & Company 98
McClanahan, B. F. 82
McElrath, Thos. H. 92
McKenzie 8, 24, 38, *49*, 88
McKnight Broothers 66, 80
McLemoresville 56
McNanee 61
McNairy County 3, 11, 12, *106*
McNeal Springs 76
Medon 103
Memphis 4, 6, 7, 13, 14, 15, 38, *110*
Memphis Stone and Gravel Company 58
Middleburg 77
Middleton 38, 77
Milan 3, 8, 21, 27, 38, *69*
Mills, chaser 33
Mills, pug 32
Mining of clay 30
Mississippi River 10, 17, 18, 24
Mississippian series **9**
Mixtures of clays 22
Mobile and Ohio 6
Monroe wad mine 96
Moore, A. M. 79
Moscow 27, *63*
Mud, stiff 34
Mud temperers 37
Mud wheelers 37

—N—

Nashville 27
Nashville, Chattahooga and St.
  Louis 6, 7, 9
Nashville Pottery pit 87
Newbill Crossroads 55
New Boston 91
New Madrid earthquake 4, 5, 6
Nichols, J. M. 59
Nonconnah Pottery Company 109
Novaculite 7, 16, 58

—O—

Obion 28, 38, 108
Obion County 107
Obion River 3, 18, 25
Offbearers 37
Orange sands 16

Page
Origin of topography 4
Output of stoneware, 1909 39

—P—

Palestine pit 88
Paleozoic rocks 8, 15
Pan-drying 31
Paris 3, 7, 13, 17, 23, 24, 38, *91*
Parnell, Ed 55
Parsons 9
Pate, Andy 52
Perryville 58
Physical tests 28, 29, 30
Piney creek 12
Pinson 24, 27, *104*
Pinson Pottery Company 104
Pipkin, Joe 77
Pleistocene 8, 17
Pliocene 8, 16, 23
Polk, Mrs. Octavia 76
Porcelain 22
Porter's Creek Formation....
  ....4, 58, 13, 24, 26
Potteries 39, 49, 77, 91, 104, 109
Pottery pits 24, 91
Potter's clay 19, 30
Press, dry 34
Price of lands 6
Pug mill 32
Puryear 16, 92

—Q—

Quaternary system 17

—R—

Rackers 37
Railroads and towns....
  ....40, 56, 57, 58, 60, 64, 65, 73, 79,
  80, 81, 83, 97, 98, 99, 109, 111, 112
Railway facilities 6, 7
Reelfoot Lake 4
Repressing 35
Repress machine 35
Residual ridge 3
Reynoldsburg 13
Richard, Robt. 79
Ries, ...1, 20
Ripley sands 3, 8, 11, 12, 23, 25, 27
Ripley 8, 38, *98*